**Journal of Diseases and Medicinal Plants**
2023; 9(4): 100-128
http://www.sciencepublishinggroup.com/j/jdmp
doi: 10.11648/j.jdmp.20230904.11
ISSN: 2469-8202 (Print); ISSN: 2469-8210 (Online)

# An Overview of Metabolic Syndrome and Cameroonian Natural Agents Use in the Management of Associated Factors

**Fabrice Fabien Dongho Dongmo[1, *], Diana Ngo Hagbe[1, †], Guileine Linda Dongho Zongning[1, †], Suzie Vanissa Nkepndep Touohou[1, †], William Djeukeu Asongni[2], Ghislain Maffo Tazoho[3], Landry Lienou Lienou[1], Aymar Rodrigue Fogang Mba[1], Nicolas Policarpe Nolla[1], Rebecca Madeleine Ebelle Etame[1], Rosalie Anne Ngono Ngane[1], Inocent Gouado[1]**

[1]Department of Biochemistry, Faculty of Science, University of Douala, Douala, Cameroon

[2]Department of Home Economic, Advanced Teacher's Training College for Technical Education, University of Douala, Douala, Cameroon

[3]Department of Biochemistry, Faculty of Science, University of Dschang, Dschang, Cameroon

## Email address:

donghofabrice@gmail.com (Fabrice Fabien Dongho Dongmo)

[*]Corresponding author

† Diana Ngo Hagbe, Guileine Linda Dongho Zongning and Suzie Vanissa Nkepndep Touohou are co-second authors.

## To cite this article:

Fabrice Fabien Dongho Dongmo, Diana Ngo Hagbe, Guileine Linda Dongho Zongning, Suzie Vanissa Nkepndep Touohou, William Djeukeu Asongni, Ghislain Maffo Tazoho, Landry Lienou Lienou, Aymar Rodrigue Fogang Mba, Nicolas Policarpe Nolla, Rebecca Madeleine Ebelle Etame, Rosalie Anne Ngono Ngane, Inocent Gouado. An Overview of Metabolic Syndrome and Cameroonian Natural Agents Use in the Management of Associated Factors. *Journal of Diseases and Medicinal Plants*. Vol. 9, No. 4, 2023, pp. 100-128.
doi: 10.11648/j.jdmp.20230904.11

**Received**: August 24, 2023; **Accepted**: September 14, 2023; **Published**: October 8, 2023

**Abstract:** Metabolic syndrome (MetS) is a group of metabolic disorders that include central obesity, hyperglycaemia, dyslipidemia, hypertension and having an increasing risk of developing cardiovascular diseases. Cameroon, is encounting a significant increase in the prevalence and associated factors in recent decades. In fact, the existing literature showed the prevalence of MetS in Cameroon from 7.0 to 41.1% according to the area and period of study and to the concerned specific groups. It is the same for the associated factors with a prevalence of 8.0 to 69.1% for obesity and overweight; 3.4 to 75.4% for dyslipidaemia; 4.8 to 20.5% for diabetes; and 4.1 to 46.5% for hypertension. For the management of MetS and associated factors, natural substances are complementary or alternative choices regarding the limited side effects of common chemical therapeutics. Cameroonian biodiversity offers a wide variety of natural substances. The present review briefly overviews the MetS and identifies from literature, natural agents useful in the management of MetS and associated factors in Cameroon. Ethnomedicine and ethnobotany studies revealed plant resources of which 18 species are used for at least three associated factors, 195 for one or two factors. Studies done on biological properties revealed five resources, plants being the most represented of which 63 active on at least three factors and 66 on one or two factors. The other resources represented by mushrooms (11 species), marine products (08 species of fishes and 01 species of algae), insects (02 species) and probiotics (02 species) were active on at least two factors. A total of 312 species of which 288 plants are identified useful for management of MetS and associated factors in Cameroon.

**Keywords:** Metabolic Syndrome, Overview, Management, Natural Substances, Cameroon

## 1. Introduction

Metabolic syndrome (MetS) is a group of several disorders, which raise the risk of an individual to develop atherosclerotic cardiovascular disease, insulin resistance, diabetes mellitus, vascular and neurological complications such as a cerebrovascular accident [1, 2]. Its pathophysiology encompasses several complex mechanisms that are yet to be

fully elucidated. It is still debated as to whether the different elements of MetS form by themselves distinct pathologies or fall under a common and broader pathogenic process [1]. In addition to genetic and epigenetic factors, lifestyle and environmental factors such as overeating and lack of physical activity have been identified as major contributors to the development of MetS. A causative role can be given to high caloric intake since visceral adiposity has been shown to be an important trigger that activates most of the pathways of MetS [1, 3]. MetS has become increasingly important in recent decades due to the exponential increase in obesity worldwide [4]. Worldwide prevalence is ranged from <10% to as much as 84%, depending on the region, urban or rural environment, composition (sex, age, race and ethnicity) of the population studied and the definition of the syndrome used. The IDF estimates that one-quarter of the world's adult population has the MetS [3, 5, 6]. In Africa, the overall prevalence of MetS varies from 11.10 to 23.90% according to the different diagnostic criteria [7].

Concerning the management of MetS, treating the conditions contributing to metabolic syndrome and possibly reverting the risk factors are often targeted. Thus, modifiable factors such as diet and exercise should be emphasised in patients with MetS [3, 8]. Besides, other approaches are surgery and conventional pharmacology and the use of hypotensive, hypoglycaemic and cholesterol-lowering drugs [4]. Regarding the limited side effects for common chemical therapeutics, there has been growing interest in medications including natural substances, viewed their ease of access, as complementary or alternative choice for prevention or treatment of MetS.

Natural substances occur in nature and can be obtained from plants, animals, or other organisms [9]. Most natural substances are complex mixtures of compounds belonging to classes of chemical substance e.g. alkaloids, lipids, peptides, phenolics, sugars and terpenes. These compounds are known to have numerous biological activities and health benefits for prevention and treatment of many diseases among which MetS [10]. Certain phytomolecules derived from aromatic plants have good virtues for the management of MetS. It is the case of curcumin from Turmeric [11, 12], flavonoids and anthocyanins from roselle [13], gingerol from ginger [14], green tea catechins, caffeine, berry anthocyanins, cocoa polyphenols and monocolors [15]. Moreover, ω-3 and ω-6 fatty acids series are precursors of the synthesis of prostaglandin and leukotriene, which are involved in coagulation and inflammation processes respectively [16]. Besides, some animal-derived products such as fish oils due to their richness in ω-3 polyunsaturated fatty acids have beneficial effects in reducing and preventing cardiovascular disease in general and MetS in particular [17].

In Cameroon, there is lack information on the country's prevalence of MetS. However, there are enough data concerning prevalence of different factors associated to MetS both at national level in some areas and of specific groups. Regarding MetS prevalence, available data shows a prevalence varying from 5.4 to 41.1% according to age, sex, locality and studied groups [18-22]. As for prevalence of factors associated with MetS, in Cameroon, global prevalence was 11.4% among adults in 2016 and 11% among children under 5 in 2019 [23]. Moreover, some studies showed a prevalence of overweight and obesity varying from 8.0 to 55.5% [24--29]. Concerning dyslipidaemia, studies showed a prevalence of 3.4 to 59.7% [30, 31, 32]. Diabetes on the other hand has an overall prevalence is 4.8 to 5.8% in adults [33, 34]. Some studies showed a prevalence of 9.4 to 20.5% [35, 36]. For hypertension, Kuate et al. [37] noted an overall prevalence of 30.9%. Others studies revealed a prevalence of 4.1 to 46.5% [38-42]. These data show that MetS and its associated factors are a real public health problem in Cameroon, needing particular attention. As earlier said, natural substances will be complementary or alternative choices regarding the limited side effects for common chemical therapeutics. Fortunately, Cameroon is a nation of beauty and biological diversity. In fact, its fauna and flora biodiversity was ranked 21$^{st}$ globally and 4$^{th}$ in Africa in 2018 according to the World Wildlife Fund [43]. This diversity offers a wide variety of natural substances that can be used for the management of diseases, among which MetS and associated factors. There are numerous ethnomedicinal and ethnobotanic studies focused on Cameroonian natural agents' used for management of factors associated with MetS including obesity, dyslipidaemia, diabetes and hypertension. Also, numerous studies have been done on biological activities of natural agents against factors associated with MetS.

To the best of our knowledge, no review focused on studies done on Cameroonian's natural agents useful in the management of factors associated with Mets have been reported. Based on this, the main objective of the present review was to identify from existing literature, the natural agents found in Cameroon useful in the management of MetS and factors associated. First and foremost, an overview of MetS was provided, including their definition, pathophysiology, epidemiology and management.

# 2. Overview of Metabolic Syndrome

According to Reaven in 1988, insulin resistance is not only involved in the aetiology of type 2 diabetes mellitus (T2DM) but also that of cardiovascular disease. He remarked that IR frequently presents in conjunction with a set of abnormalities and described them as syndrome X. The qualifier "metabolic" was added to Reaven's syndrome X to differentiate it from the pre-existing syndrome X in cardiology. In sum, metabolic syndrome X is a risk factor for cardiovascular diseases even without concomitant T2DM and it includes insulin resistance, hyperinsulinemia, dysglycemia, dyslipidaemia and hypertension. The disorders are, respectively, assessed using six indices to make the diagnosis of MetS: waist circumference, fasting glucose levels, triglyceride levels, high-density lipoprotein (HDL) levels, cholesterol levels and blood pressure [1, 2].

### *2.1. Definition*

MetS is a health condition predisposing to the onset of type

2 diabetes, arteriosclerosis, cardiovascular disease and its complications. It includes insulin resistance, obesity, high blood pressure, dyslipidaemia (low HDL and/or high triglycerides), microalbuminuria and glucose disorder [1]. However, according to expert, different definition are given to MetS Previously, the usual definitions were those of the WHO in 1998, the European Group for the study of insulin resistance (EGIR) in 1999, the National Cholesterol Education Program Expert Panel on Detection, Evaluation and Treatment of Blood Cholesterol in Adults (NCEP-ATP III) in 2001 and the International Federation of Diabetes (IFD) in 2005 [1, 3]. In 2009, a consensus definition of MetS was established by the IDF, the National Heart, Lung and Blood Institute, the American Heart Association, the WHO, the International Atherosclerosis Society (IAS) and the International Association for the Study of Obesity [1]. The definition of this syndrome focuses on the presence of at least three of these five factors including fasting hyperglycaemia, hypertriglyceridemia and plasma decrease in HDL-C, hypertension and abdominal obesity [2, 44]. It is also considered as a combination of morphological, physiological, biochemical, clinical and biological abnormalities that evolve relatively over time and coexist in the same individual in a non-random manner [1]. Table 1 below summarises all the criteria for defining MetS.

***Table 1.*** *Evolution of metabolic syndrome diagnostic definitions throughout the years [1].*

| CLINICAL MEASURE | CRITERIA | | | | | DIAGNOSIS |
|---|---|---|---|---|---|---|
| | **Central Obesity** | **Blood glucose** | **High triglyceride** | **Low HDL cholesterol** | **High blood pressure** | |
| AHA/NHLBI (2009) | Waist circumference >102 cm (men) or >88 cm (women) | Impaired fasting glucose or on high blood glucose treatment or T2DM diagnosis | ≥150 mg/dL or on triglyceride treatment | <40 mg/dL (men) or <50 mg/dL (women) or on HDL cholesterol treatment | ≥130 mmHg systolic and/or ≥85 mmHg diastolic or on hypertension treatment | ≥3 criteria |
| IDF (2005) | Waist circumference >94 cm (men) or >80 cm (women) BMI >30 kg/m$^2$ | | | | | ≥3 criteria one of which should be central obesity |
| ATPIII (2001) | Waist circumference >102 cm (men) or >88 cm (women) | | | <40 mg/dL (men) or <50 mg/dL (women) | ≥130 mmHg systolic and ≥85 mmHg diastolic or on hypertension treatment | ≥3 criteria |
| EGIR (1999) | Waist circumference >94 cm (men) or >80 cm (women) | Impaired fasting glucose or Impaired fasting glucose | ≥150 mg/dL | <39 mg/dL (men and women) | ≥140 mmHg systolic and ≥90 mmHg diastolic or on hypertension treatment | ≥3 criteria one of which should be insulin resistance * |
| WHO (1998) | Waist/hip ratio > 0.9 (men) or > 0.85 (women) or BMI > 30 kg/m$^2$ | Impaired fasting glucose or Impaired glucose tolerance or T2DM diagnosis | | <35 mg/dL (men) or <39 mg/dL (women) | ≥140 mmHg systolic and ≥90 mmHg diastolic | ≥3 criteria one of which should be insulin resistance ** |

Note that impaired fasting glucose is defined as ≥110 mg/dL in 2001 but this was modified in 2004 to be ≥100 mg/dL, Impaired glucose tolerance is defined as 2 h glucose >140 mg/dL.

* EGIR insulin resistance is defined as plasma insulin levels >75th percentile. ** WHO insulin resistance is defined as presence of insulin resistance or impaired fasting glucose or impaired glucose tolerance.

Abbreviations: AHA: American Heart Association, ATPIII: National Cholesterol Education Program Adult Treatment Panel III; BMI: body mass index; EGIR: European group for study of insulin resistance; HDL: high density lipoprotein; IDF: International Diabetes Federation; NHLBI: National Heart, Lung and Blood Institute; WHO: World Health Organization

### *2.2. Epidemiology*

Worldwide prevalence of MetS ranges from <10% to as much as 84%, depending on the region, urban or rural environment, composition (sex, age, race and ethnicity) of the population studied and the definition of the syndrome used [1]. The IDF estimates that one-quarter of the world's adult population has the MetS. Higher socioeconomic status, sedentary lifestyle and high body mass index (BMI) were significantly associated with MetS. Also, it has been noted that the differences in genetic background, diet, levels of physical activity, smoking, family history of diabetes and education influence the prevalence of MetS and its components [3, 5]. In fact, a study conducted worldwide on 45811 participants showed that the prevalence of MetS was 23.7% with a substantial heterogeneity of 98.2% [6]. Analysis of subgroups based on geography found that the highest prevalence was observed in Australia (27.3%). In addition, Noubiap et al. [45] noted in a systematic review that the global prevalence of MetS in 2020 was 2.8% among the children (25.8 million children) and 4.8% among adolescents (35.5 million adolescents). They also found that the prevalence of metabolic syndrome was not consistently higher with increasing levels of development. In another systematic review, Noubiap et al. [46] showed that the MetS global prevalence among adults varied from 12.5% to 31.4% according to the definition considered. This prevalence was significantly higher in the Eastern Mediterranean Region and Americas and increased with the country's level of income.

Africa is also not to be outdone. In fact, a study conducted among 34324 healthy participants aged 16 years and more in sub-Saharan Africa [7] showed a prevalence of MetS from 11.10% to 23.90% according to diagnostic criteria. The highest prevalence was observed in women and in Southern Africa, followed by Eastern, West and Central Africa.

### *2.3. Pathophysiology of Metabolic Syndrome*

The pathophysiology of the MetS encompasses several complex mechanisms that are yet to be fully elucidated. There are still debates on whether the different elements of MetS form by themselves distinct pathologies or fall under a common, broadern pathogenic process. In addition to genetic and epigenetic factors, some lifestyle and environmental factors such as overeating and lack of physical activity have been identified as major contributors to the development of MetS. A causative role can be given to high caloric intake since visceral adiposity has been shown to be an important trigger that activates most of the pathways of MetS [1, 3]. Among the proposed mechanisms, insulin resistance, chronic inflammation and neurohormonal activation seem to be essential players in the progression of MetS and its subsequent transition to cardiovascular diseases and T2DM.

In fact, after meals, the body through digestion recovers nutrients from food and stores them in peripheral tissues to reuse them timely [47, 48]. Glucose is stored as glycogen in the liver and muscles during glycogenesis. Glucose is also used to build up the stock of fat mass by giving fatty acids that are assembled in triglycerides at the level of adipose tissue and a little hepatic during lipogenesis. Amino acids are grouped together to form proteins essential to cells in their structure and function. All these physiological processes are dependent on the correct signalling by protein enzymes and their target receptors at each step. The liver is an organ involved in lipid, carbohydrate and protein metabolism [47, 48]. MetS can have hepatic consequences, including metabolic steatopathies due to insulin resistance. Conversely, steatopathies can lead to MetS [49].

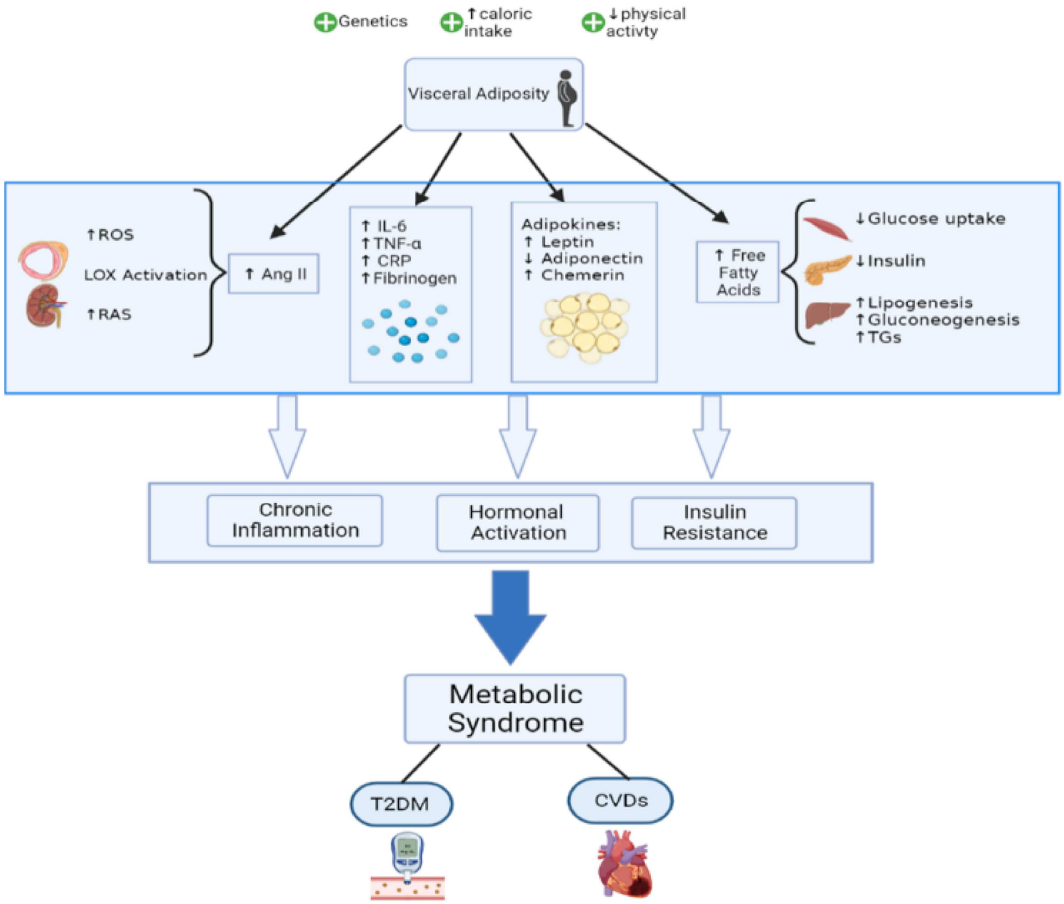


***Figure 1.*** *Mechanisms highlighting MetS pathophysiology [1].*

Legend: ↑: Increase, ↓: Decrease, Ang II: Angiotensin II, CRP: C reactive protein, CVDs: Cardiovascular diseases, IL-6: interleukin-6, LOX-1: Lipoprotein receptor-1, ROS: Reactive oxygen species, T2DM: Type 2 diabetes mellitus, TGs: Triglycerides, TNF-α: Tumour necrosis factor-α

Although the molecular basis underlying MetS remains incompletely elucidated, the recent evidence of multiple peptide secretions by adipose tissue has placed the adipocyte at the centre of the process leading to the clinical expression of the various disorders of this syndrome. The obese subject, by its greater fat mass, will therefore be predisposed to a secretory dysfunction of the adipocyte. Several genes responsible for overweight have recently been identified.

This genetic predisposition is amplified by environmental factors whose growing importance within different population groups explains the progression of MetS in many countries of the world. These factors associate a high-calorie diet high in fat and fast-absorbing sugars with insufficient physical activity. The topography of fat mass distribution plays an important role in the onset of metabolic and cardiovascular risks in humans. Indeed, it is abdominal/android obesity that is associated with this risk, unlike hip/gynoid obesity. Among the abdominal adipocytes, the omental adipocytes are the most concerned. Thus, waist circumference measurement becomes a very useful anthropometric measure in addition to BMI [1, 3, 50, 51]. The deregulation of lipid metabolism induced by the accumulation of adipose tissue leads to the development of insulin resistance, whose metabolic consequences are at the heart of the evolutionary process of MetS clearly elucidated by Figure 1.

A high accumulation of adipose tissue in the abdominal area is a more important risk factor for cardiovascular disease, insulin resistance and T2DM. Indeed, adipose tissue, divided into brown adipose tissue and white adipose tissue regulates many metabolic pathways which can lead to impaired carbohydrate and lipid metabolism if altered. Brown adipose tissue regulates adaptive thermogenesis while the white adipose tissue represents the storage site for lipids, releasing them as energy when needed. In addition, white adipose tissue secretes leptin, adiponectin, adipsin, fatty acid binding protein 4, hydroxylated fatty acid esters and palmitoleate which act on the pancreas, liver, skeletal muscles, cardiovascular system and brain. White adipose tissue is in turn divided into visceral adipose tissue and subcutaneous adipose tissue. Only the latter is associated with cardiovascular system morbidity, as it determines a significant release into the blood pro-inflammatory fatty acids and cytokines, such as interleukin (IL)-6, IL-8 and tumour necrosis factor-α (TNF-α). It also secretes plasminogen activator inhibitor-1 (PAI-1) capable of promoting a prothrombotic state. Excessive calorie intake causes adipocyte hyperplasia and hyperplasia, as is the case in obese subjects, leading to metabolic alterations and the onset of a chronic low-grade inflammatory state [1, 3, 50-54].

Pro-inflammatory substances released from adipose tissue can cause insulin resistance, T2DM, metabolic and cardiovascular diseases. Atherogenic dyslipidaemia is characterised by an increase in circulating triglyceride levels, a reduction in HDL-cholesterol levels and therefore, an increase in LDL-cholesterol). These alterations are closely related to impaired insulin metabolism. Indeed, in case of insulin resistance, it is possible to observe an increase in lipolysis and levels of apolipoprotein B (apoB) and very low density lipoproteins (VLDL), as well as a dysfunction of lipases that leads to a reduction in the clearance of VLDL. Therefore, there will be a significant amount of triglyceride-rich HDL lipoproteins, obtained from VLDLs, which will be rapidly eliminated by hepatic lipase, with a reduction in circulating HDL levels. Chronic low-grade inflammatory status, insulin resistance and impaired lipid profile could lead to endothelial dysfunction [1, 50-52, 54, 55].

Hyperglycemia can cause an increase in endothelial cell glucose, promote oxidative degradation of glucose metabolites and result in oxidative stress. In addition, they increase levels of advanced glycation end products (AGEs) involved in vascular damage processes. Another factor that induces endothelial dysfunction in MetS patients is insulin under physiological conditions, could exert a vasodilating action; indeed, insulin acts on the phosphorylation of endothelial nitric oxide synthase (eNOS) which causes the increase of nitric oxide (NO), capable of inducing vasodilation. Impaired phosphorylation of eNOS may result in increased bone, inflammation, prothrombotic statusand BP values [1, 50, 54-57].

### *2.4. Management of Metabolic Syndrome*

The management of MetS is targeted by treating the conditions contributing to metabolic syndrome and possibly reverting the risk factors. Thus, modifiable factors such as diet and exercise should be emphasised in patients with MetS [3, 8].

Nutrition is a key environmental factor for metabolic syndrome. During the last decades, increasing scientific evidence has emerged that protective health effects can be obtained from diets that are rich in fruits, vegetables, legumes and whole grains and which include fish, nuts and low-fat dairy products. Such diets need not be restricted in total fat intake as long as energy intake does not exceed caloric expenditure and if they emphasise predominantly vegetable oils that have a low content in saturated fats and partially hydrogenated oils. The intake of specific nutrients may have different effects on the development of MetS characteristics, their roles in treatment should be clarified. Thus, consumption of wrong carbohydrates such as simple sugars should be avoided in favour of complex carbohydrates and fibres. Unsaturated fats, derived mostly from vegetable oils, are recommended compared to saturated ones. Studies suggest that we only need relatively small amounts of protein for good health. Increased protein intake may be detrimental for obese persons and those with kidney disease. In addition, micronutrients and phytonutrients such as polyphenols have antioxidant and anti-inflammatory activities and control multiple metabolic processes and enzymatic activities. Some of these micronutrients are essential and recommended worldwide for supplementation to prevent deficient pathological conditions, including diabetes and insulin resistance. However, it is indicated that overdose of these micronutrients and phytonutrients could have adverse effects on health [8, 58, 59].

Concerning exercise, several observational studies in the 1970s suggested that mortality or morbidity caused by atherosclerotic and metabolic diseases was inversely related to the individual's physical activity status. The protective role of physical activity has been attributed to various mechanisms. Furthermore, physical exercise has favourable effects on traditional cardiovascular risk factors; the positive

effect can be attributed to a direct action of physical activity on the heart itself leading to increased myocardial oxygen supply, decreased myocardial oxygen demands and formation of collateral coronary circulation, improved myocardial contraction and electrical stability of the heart. The theoretical mechanism for chronic exercise promoting a reduction in body fat involves increased total daily energy expenditure without a corresponding increase in energy intake [3, 8, 58].

Besides modifiable factors such as diet and exercise, other approaches to manage MetS are surgery and conventional pharmacology. The newest consist of using hypotensive, hypoglycaemic and cholesterol-lowering drugs. However, a single drug treatment alone could not effectively manage the effects of MetS. In addition, the currently available drug therapy and comorbidities associated with MetS imply a long and repeated intake of the many drugs thus constituting a difficulty for the patient because of polypharmacy and reduced compliance [4]. Regarding the limited side effects for common chemical therapeutics, there has been growing interest in medications including natural substances, viewed their ease of access, as complementary or alternative choices for prevention or treatment of MetS. In fact, it has been shown that natural substances or their derivatives are a valuable source of therapeutic agents. Indeed, researchers have focused on natural products in the field of management of MetS.

# 3. Natural Substances and Management of Metabolic Syndrome

There are various definitions for natural substances, for example according to REACH 'substances which occur in nature: means a naturally occurring substance, unprocessed or processed only by manual, mechanical or gravitational means, by dissolution in water, by flotation, by extraction with water, by steam distillation, or by heating solely to remove water or which is extracted from air by any means'. They are obtained from plants, animals, or other organisms [9]. Most natural substances are complex mixtures of compounds belonging to various chemical substance classes, e.g. alkaloids, lipids, peptides, phenolics, sugars and terpenes. These compounds are known to have numerous biological activities and health benefits for prevention and treatment of many diseases among which MetS. In fact, it has been shown that bioactive compounds can be used as a strategy for the prevention of the onset and treatment of metabolic disorders such as MetS thus improving inflammatory status and other comorbidities such as obesity, dyslipidaemia and cardiovascular disease [10].

Some phytomolecules derived from aromatic plants have good virtues for the management of MetS. Indeed, curcumin from Turmeric has hypoglycaemic effects as it facilitates the sensitivity of cells to insulin [11]. It also has the ability to positively regulate the expression of the GLUT2, GLUT3 and GLUT4 genes, which are uniport pancreatic glucose transporters, thus stimulating insulin secretion [60]. In addition, associated to piperine, it increased in MetS patients' serum HDL cholesterol while reducing LDL and total cholesterol, cytokine and pro-inflammatory adipokines such as TNF-α, IL-6, IL-1β and MCP-1 [12]. Similarly, flavonoids and anthocyanins from roselle would have an effect on the reduction of serum triglycerides [13]. Gingerol from ginger has shown efficacy in blood sugar control as well as on insulin sensitivity [14]. Also, polyphenols, silymarin and monacolins have a beneficial effect on key MetS characteristics such as obesity, dyslipidaemia, glucose intolerance, fatty liver disease and hypertension. Green tea catechins, caffeine, berry anthocyanins, cocoa polyphenols and monocolors are effective in treating hypercholesterolemia [15].

Moreover, ω-3 and ω-6 fatty acids series are precursors of the synthesis of prostaglandin and leukotriene, which are involved in coagulation and inflammation processes, respectively. Omega-6 fatty acids participate in the inflammatory process, whereas ω-3 fatty acids activate the anti-inflammatory pathway. Eicosanoid production by platelets and cells in the vascular wall modulates physiological processes, such as arterial compliance, fluidity and platelet aggregation contributing to minimise atherosclerosis risk. The balance between the production of anti-inflammatory and inflammatory prostaglandin is essential to prevent thrombotic complications. Overall, the appropriate consumption of the two fatty acids series (ω-3 and ω-6) ensures the balance necessary to control the coagulation and inflammation processes [16]. Besides, some animal-derived products such as fish oils due to their richness in ω-3 polyunsaturated fatty acids have beneficial effects in reducing and preventing cardiovascular disease in general and MetS in particular [17].

# 4. Epidemiology of Metabolic Syndrome and Associated Factors in Cameroon

To the best of our knowledge, there is no data concerning MetS prevalence of all the Cameroonian population. However, there are studies determining MetS prevalence conducted in some areas and in specific groups. Nonetheless, there is enough data concerning prevalence of different factors associated with MetS both at national level and in some areas and in specific groups. Regarding MetS prevalence, Lemogoum et al. [18] noted among 2180 Cameroonian adults in rural and urban Cameroon a prevalence of 20.6% for obesity, 5.4% for diabetes, 31.7% for hypertension and 20.1% for hypercholesterolemia. Also, Mfeukeu-Kuaté et al. [19] noted a prevalence of MetS of 41.1% among 236 adult populations working in a Cameroonian local enterprise. A cross-sectional study conducted among 604 Bamboutos Division's adults [20] showed a prevalence of MetS of 32.5% with highly significant female predominance (46.1%). The most common abnormalities were low-HDL (82.8%) and

hypertriglyceridemia (54.0%). Participants with obesity and overweight had a higher risk of developing MetS. Another study conducted among pregnant women aged 17 to 45 years in the regions of Central and of Littoral showed a MetS prevalence of 7.0% with hyperglycaemia of 47.1% [21]. In addition, a study conducted in 604 pregnant women at the district hospital of Dschang showed a prevalence of MetS of 17.9% with hypertriglyceridemia of 28.0% and low HDL cholesterol of 66.2% [22]. Likewise, a cross-sectional study in the Douala general hospital from January to March 2016, including chronic kidney diseases patients showed the prevalence of hypertension of 90.3%, obesity of 79.5% and of dyslipidaemia of 69.8% [61].

For the prevalence of factors associated with MetS, globally, in Cameroon, 11.4% of adults were obese in 2016 against 9.8% in (2012). About 11% of children under 5 were overweight in 2019 against 6.5% in 2012 [23]. Moreover, Tchoubi et al. [25] have reported a prevalence of obesity and overweight of 8.0% among children aged 6 to 59 months in Cameroon in 2011 while Fouedjeu et al. [24] noted in children of 8-15 years at Douala a prevalence of 14.3% in (2010). Concerning adults, Engle-Stone et al. [26] reported a prevalence of obesity and overweight of 22-55.5% among women. Also, Nyangono et al. [27] found in Douala town a prevalence of obesity and overweight of 54.2% among adults of both sex in 2016 while Simo et al. [28] noted a prevalence of 50.1% among adults of both sex in the West region in (2018). Likewise, a cross-sectional study conducted from September 2015 to March 2016 on 1,006 apparently healthy adults aged 20 - 70 years at West and North-West regions showed that 36.6% were overweight, 33.1% were obese and 69.1% were overweight/obese with abdominal fat accumulation [29].

Concerning dyslipidaemia, Yangoua et al. [30] noted in Yaoundé in a 1986 individuals aged 20 - 65 years the prevalence of hypercholesterolemia of 19.3%, hypertriglyceridemia of 11.6%, low HDL-cholesterolemia of 75.4%, combined dyslipidaemia of 3.40% and atherogenic profile of 40.5%. Also, a study in the North West Region included 415 healthy children aged 5-16 years showed a prevalence of dyslipidaemia of 46.0% [32]. Moreover, Mbouemboue et al. [62] noted among diabetic patients in Ngaoundere the occurrence of dyslipidemias, hypercholesterolemia, hypertriglyceridemia and mixed hyperlipidemia of 59.7%, 49.5%, 7.0% and 3.2% respectively between 2014 and (2015). Likewise, Moor et al. [31] showed among overweight and obese adults in Yaoundé a prevalence of dyslipidaemia of 52.9%, with main subtypes HDL hypocholesterolaemia (54.4%) and hypertriglyceridemia (47.1%).

About diabetes, International Diabetes Foundation estimated a prevalence of 4.8% in Cameroonian adults [34]. A systematic review and meta-analysis on studies published between January 2000 and April 2017 did by Bigna et al. [33] among apparently healthy adults residing in Cameroon showed an overall prevalence of diabetes mellitus of 5.8% in a pooled sample of 37,147 participants and a prevalence of pre-diabetes of 7.1% in a pooled sample of 5,872 people. They also revealed that this prevalence increased with age, hypertension, overweight and obesity. Egbe et al. [35] noted a prevalence of 20.5% of gestational diabetes mellitus among pregnant women in the South West Region of Cameroon. Moreover, a study showed a prevalence of 9.4% of diabetes in Central prison of Yaoundé with sedentary, smoking and alcohol consumption as the main risk factors [36].

For hypertension, a systematic review and meta-analysis of population-based studies conducted through November 2018 on hypertension studies among Cameroonians of at least 18 years showed an overall hypertension prevalence was 29.6% in 1994-2010 and 32.1% in 2011-2018 for a mean prevalence of 30.9% [37]. Afterward, Bika et al. [38] noted among 406 pygmies of Southern region Cameroon the age-standardised prevalence of hypertension in urban Bantus, rural Bantus, urban Pygmies and traditional Pygmies was 18.0, 13.5, 9.3 and 4.1%, respectively. Likewise, Nganou-Gnindjio et al. [39] noted a prevalence of hypertension of 12% and 8.6% in Cameroonian urban and semi-urban areas respectively. Ntentie et al. [42] noted among students of the University of Maroua the prevalence of hypertension of 8.2%. Dakam et al. [40] showed among elderly persons at Foumban city the prevalence of 29.7% of hypertension associated with abdominal obesity, 37.8% of hypertension associated with generalised obesity and 46.5% of hypertension associated with abdominal obesity. Fokam et al. [41] noted a prevalence of hypertension of 17.8% among long-distance bus drivers stationed in Yaoundé.

## 5. Natural Agents Useful in the Management of Factors Associated to Metabolic Syndrome in Cameroon

Cameroon, located on the west coast of Africa between Nigeria and Equatorial Guinea, is a nation of incomparable beauty and biological diversity. Mount Cameroon, in the South-West, is one of Africa's largest volcanoes; in the north of the country, savanna and semi-desert extend to Lake Chad; and in the south, lush tropical rain forests form the northwestern boundary of the Congo basin. According to a 2018 ranking published by the World Wildlife Fund, Cameroon's fauna and flora biodiversity ranks 21$^{st}$ globally and 4$^{th}$ in Africa [43].

This fauna and flora diversity offers a wide variety of natural substances that can be used for the management of diseases, among which MetS and associated factors. Cameroonian natural agents that would be useful in the management of factors associated with MetS were identified from existing data in literature. Targeted publications were those focused on ethnomedicinal and ethnobotanic studies and from research studying biological properties of local resources. Thus, the searches were conducted in databases Google Scholar, PubMed, ScienceDirect and ResearchGate until October (2022). Search terms (keywords) were Cameroon, MetS, obesity, dyslipidaemia, diabetes,

hypertension, management, natural resources/products. Only studies conducted with natural resources/products from Cameroon and dealing with at least one factor associated with MetS were included.

### *5.1. Identified Agents from Ethnomedicinal and Ethnobotanic Studies*

Many studies have been conducted on medicinal plants used for treatment or prevention of factors associated to MetS or on ethnobotanic and phytopharmacopoea in many localities of Cameroon. Indeed, Noumi et al. [63] studied plants used for the treatment of hypertension in Bafia; Din et al. [64] inventoried and identified plants used in the treatment of diabetes in Douala town; Koyeu et al. [65] inventoried anti-diabetic plants in the Nkoung–Khi division (West region). Also, Tsabang et al. reviewed the treatment of diabetes and/or hypertension using medicinal plants of Cameroon [66]; studied ethnomedical and ethnopharmacological of plants used for potential treatments of diabetes and arterial hypertension by indigenous people in coastal humid rain forests, continental humid rain forests and Soudano-Zambezian and Guinean savannahs [67]; herbal medicine and treatment of diabetes in Cameroon [68]; and presented the importance of food plants in the prevention and treatment of diabetes in Cameroon [69]. Similarly, Epoh et al. [70] studied medicinal plants used as anti-obesity remedies in Foumban and Dschang cities (West-Cameroon) while Tankeu et al. [71] studied plants with antihypertensive properties in the city of Nkongsamba. Otherwise, ethnobotany and phytopharmacopoea studies were done in South-West ethnoecological region [72]; in Aguambu – Bamumbu in the Lebialem highlands, southwest [73]; in upper Nyong valley forest [74]; in littoral and south west regions and sudano-sahelian ethnoecological region [75]; in Mount Cameroon region [76]; in Bassa area of Douala town [77]; in ethnic communities in Douala [78]; in Takamanda Rainforest South West [79]; in Mbam and Inoubou Division [80]; and in Yagoua Sub-Division, Far-north region [81].

These studies revealed, as shown in tables 2, 3 and 4, the existence of about 213 plant species used for the management of factors associated with MetS in Cameroon. Of these 213 plants, as shown in table 2, only one (*Vernonia guineensis*) is used for to manage of all the four factors associated to MetS while 17 species are used for three factors at least including 11 for obesity, diabetes and hypertension; five for dyslipidaemia, diabetes and hypertension; and one for obesity, dyslipidaemia and diabetes.

***Table 2.*** *Cameroonian medicinal plants used for treatment or prevention of at least three factors associated to MetS.*

| Families | Species | Organs Used |
|---|---|---|
| *Obesity, dyslipidemia, diabetes and hypertension* | | |
| Asteraceae | *Vernonia guineensis* | Roots |
| *Obesity, dyslipidemia and diabetes* | | |
| Cucurbitaceae | *Zehnaria scabra* | Whole plant, leaves |
| *Obesity, diabetes and hypertension* | | |
| Annonaceae | *Annona muricata* | Leaves |
| | *Xylopia aethiopica* | Fruits |
| Apocynaceae | *Voacanga africana* | Fruits, bark, leaves |
| Bromeliaceae | *Ananas comosus* | Fruits |
| Convolvulaceae | Ipomoea *mauritiana* | Roots, starch |
| Euphorbiaceae | *Alchornea cordifolia* | Leaves, roots |
| | *Ricinodendron heudelotii* | Stem bark |
| Hypericaceae | *Harungana madagascariensis* | Roots, barks, leaves |
| Mimosaceae | *Tetrapleura tetraptera* | Bark, stem bark, fruits, seeds |
| Moraceae | *Ficus exasperata* | Bark, leaves |
| Solanaceae | *Solanum indicum* | Fruits |
| *Dyslipidemia, diabetes and hypertension* | | |
| Anacardiaceae | *Anacardium occidentale* | Leaves, bark |
| Liliaceae | *Allium sativum* | Bulbs |
| Phyllanthaceae | *Phyllanthus amarus* | Whole plant |
| | *Phyllanthus niruri* | Whole plant |
| Solanaceae | *Solanum melongena* | Fruits |

Likewise, table 3 shows that 95 species are used for at least two factors (85 for diabetes and hypertension, five for obesity and hypertension; three for obesity and diabetes; one for dyslipidaemia and hypertension; and one for obesity and dyslipidaemia).

***Table 3.*** *Cameroonian medicinal plants used for treatment or prevention of two factors associated to MetS.*

| Families | Species | Organs Used |
|---|---|---|
| *Obesity and dyslipidemia* | | |
| Acanthaceae | *Brillantaisia vogeliana* | Leaves |

| Families | Species | Organs Used |
|---|---|---|
| *Obesity and diabetes* | | |
| Apocynaceae | *Voacanga thouarsii* | Bark |
| Rubiaceae | *Hallea stipulosa* | Bark |
| Zingiberaceae | *Zingiber officinale* | Rhizome |
| *Obesity and hypertension* | | |
| Fabaceae | *Erythrina senegalensis* | Bark |
| | *Sida rhombifolia* | Leaves |
| Malvaceae | *Hibiscus sabdariffa* | Leaves, calyces |
| | *Hibiscus surattensis* | Leaves, young shoots |
| Moraceae | *Ficus platyphylla* | Bark |
| *Dyslipidemia and hypertension* | | |
| Caryophyllaceae | *Drymaria cordata* | Whole plant |
| *Diabetes and hypertension* | | |
| | *Antrocaryon klaineanum* | Bark |
| Anacardiaceae | *Sclerocarya birrea* | Leaves |
| | *Mangifera indica* | Leaves |
| | *Hexalobus crispiflorus* | Bark |
| Annonaceae | *Anonidium mannii* | Bark |
| | *Pteleopsis hylodendron* | Bark |
| | *Alstonia boonei* | Bark, leaves |
| Apocynaceae | *Catharanthus roseus* | Roots, leaves |
| | *Rauvolfa vomitoria* | Bark |
| | *Picralima nitida* | Fruits |
| | *Aloe barteri* | Leaves |
| Asphodelaceae | *Aloe buettneri* | Leaves |
| | *Aloe vera* | Leaves |
| | *Ageratum conyzoides* | Whole plant |
| | *Bidens pilosa* | Whole plant |
| Asteraceae | *Cyathula prostata* | Leaves |
| | *Eclipta prostata* | Whole plant |
| | *Vernonia ambigua* | Leaves |
| | *Vernonia glabra* | Rhizomes |
| | *Fernandoa adolfi-friderici* | Bark |
| Bignoniaceae | *Kigelia africana* | Bark |
| | *Spathodea campanulata* | Stem bark |
| Bombacaceae | *Ceiba pentandra* | Bark, leaves, roots |
| Capparaceae | *Cleome ciliata* | Leaflet stem |
| Caricaceae | *Carica papaya* | Leaves, bark, roots |
| Cecropiaceae | *Musanga cecropioides* | Bark |
| Clusiaceae | *Allanblackia floribunda* | Bark |
| | *Allanblackia gabonensis* | Bark |
| Costaceae | *Costus afer* | Whole plant |
| | *Cucumis metuliferus* | Fruits |
| Cucurbitaceae | *Momordica charantia* | Whole plant |
| | *Momordica foetida* | Leaves |
| | *Drypetes staudtii* | Bark |
| Euphorbiaceae | *Mallothus oppositifolius* | Leaves |
| | *Plagiostyles africana* | Bark |
| | *Euphorbia hinta* | Whole plant |
| | *Mucuna pruriens* | Seeds |
| | *Pterocarpus osun* | Stem bark, wood |
| | *Pterocarpus soyauxii* | Bark |
| Fabaceae | *Cylicodiscus gabunensis* | Bark |
| | *Piliostigma thonningii* | Bark |
| | *Hylodendron gabunense* | Bark |
| | *Copaifera religiosa* | Stem bark |
| | *Andira inermis* | Bark, leaves |
| Humiriaceae | *Saccoglottis gabonensis* | Bark |
| | *Desbordesia glaucescens* | Bark |
| Irvingiaceae | *Irvingia grandifolia* | Bark |
| | *Klainedoxa gabonensis* | Stipules |
| Lauraceae | *Persea americana* | Leaves |
| Liliaceae | *Allium cepa* | Bulbs |
| Loranthaceae | *Globimetula braunii* | Leaves |
| | *Phragmenthera capitata* | Leaves |
| Meliaceae | *Carapa procera* | Seeds |
| | *Entandrophragma candollei* | Bark |

| Families | Species | Organs Used |
|---|---|---|
| | *Entandrophragma cylindricum* | Bark |
| | *Entandrophragma utile* | Trunk |
| | *Khaya ivorensis* | Bark |
| | *Lovoa trichiloides* | Bark |
| | *Azadirachta indica* | Seeds, leaves, bark |
| Mimosaceae | *Albizia zygia* | Roots bark |
| Mimosoideae | *Albizia ferruginea* | Bark |
| Monimiaceae | *Glossocalyx brevipes* | Leaves |
| Moraceae | *Treculia obovoidea* | Bark |
| Moringaceae | *Moringa oleifera* | Seeds, leaves |
| Myristicaceae | *Staudtia kamerounensis* | Seeds |
| Olacaceae | *Strombosia pustulata* | Bark |
| Olacaceae | *Strombosiopis tetrandra* | Bark |
| Passifloraceae | *Barteria fistulosa* | Leaves |
| Phyllanthaceae | *Bridelia micrantha* | Bark |
| Poaceae | *Zea mays* | Female flower, 'corn beard' |
| | *Crossopterys febrifuga* | Leaves |
| | *Hallea inermis* | |
| Rubiaceae | *Morinda lucida* | Fruits |
| | *Nauclea diderrichii* | Barks |
| | *Sarcocephalus latifolius* | Roots |
| | *Stipularia africana* | Leaves |
| | *Citrus aurantifolia* | Fruits |
| | *Citrus grandis* | Fruits |
| Rutaceae | *Citrus limon* | Fruits, leaves |
| | *Zanthoxylum heitzii* | Whole plant |
| | *Zanthoxylum tessmannii* | Bark |
| Sterculiaceae | *Sterculia tragantha* | Bark |
| Tiliaceae | *Corchorus olitorius* | Whole plant |
| Ulmaceae | *Celtis tessmannii* | Bark |
| Urticaceae | *Laportea ovalifolia* | Whole plant |

Table 4 shows that 100 species are used for only one factor including 47 for hypertension, 44 for diabetes and 9 for obesity.

***Table 4.*** *Cameroonian medicinal plants used for treatment or prevention only one factor associated to MetS.*

| Families | Species | Organs Used |
|---|---|---|
| *Obesity* | | |
| Apocynaceae | *Mondia whitei* | Fruits, roots |
| Fabaceae | *Cajanus cajan* | Seeds |
| | *Irvingia gabonensis* | Seeds, bark |
| Irvingiaceae | *Irvingia wombolu* | Seeds |
| | *Sesamum indicum* | Leaves |
| Phyllanthaceae | *Hymenocardia acida* | Bark |
| Rubiaceae | *Galium asparine* | Whole plant |
| Solanaceae | *Solanum incanum* | Fruits |
| Zingiberaceae | *Aframomum melegueta* | Rhizomes |
| *Diabetes* | | |
| Acanthaceae | *Asystasia gangetica* | Leaves |
| | *Eremomastax speciosa* | Leaves |
| Annonaceae | *Enantia chlorantha* | Bark |
| Apiaceae | *Apium graveolens* | Whole plant |
| Apocynaceae | *Holarrhena floribunda* | Bark |
| Araliaceae | *Panax ginseng* | Roots |
| Arecaceae | *Cocos nucifera* | Nuts |
| Asclepiadaceae | *Leptadenia hastata* | Roots |
| Asteraceae | *Spilanthes africana* | Whole plant |
| | *Vernonia amygdalina* | Leaves |
| Baselaceae | *Basella alba* | Whole plant |
| Bombacaceae | *Adansonia digitata* | Fruits |
| Brassicaceae | *Brassica oleracea* | Leaves |
| Caesalpiniaceae | *Senna apata* | Leaves |
| Caryophyllaceae | *Drymaria cordata* | Leaves, root |
| Chenopodiaceae | *Chenopodium ombrosoides* | Leaves |
| Clusiaceae | *Garcinia mangostana* | Bark |
| Combretaceae | *Terminalia catappa* | Leaves |
| Convolvulaceae | *Ipomoa batatas* | Leaves |

| Families | Species | Organs Used |
|---|---|---|
| Crassulaceae | *Bryophyllum pinnatum* | Leaves |
| Curcubiaceae | *Cucumis melon* | Fruits |
| | *Gynostema pentaphyllum* | Bark |
| Fabaceae | *Erythrina klainei* | Back |
| | *Phaseolus vulgaris* | Pod beans |
| Gentianaceae | *Anthocleista vogelii* | Stem bark, leaves |
| Guttiferaceae | *Mammea africana* | Leaves |
| Loganiaceae | *Anthocleista vogelii* | Bark, leaves |
| | *Isoberlinia docka* | Whole plant |
| Loranthaceae | *Tapinanthus dodoneifolius* | Leaves |
| | *Tapinanthus globiferus* | Leaves, flowers |
| Mimosaceae | *Albizia coriaria* | Bark |
| | *Albizia gummifera* | Bark |
| Musaceae | *Musa sp.* | Fruits |
| Myrtaceae | *Eucalyptus saligna* | Leaves |
| | *Symphitium officinalis* | Leaves |
| | *Syzygium guineense* var. *macrocarpum* | Roots, bark |
| | *Psidium guajava* | Leaves |
| Rhizophoraceae | *Rhizophora racemosa* | Stem bark |
| Rubiaceae | *Cinchona offinalis* | Bark |
| | *Diodia serrulata* | Whole plant |
| Rutaceae | *Citrus sinensis* | Bark |
| Solanaceae | *Solanum tuberosum* | Tubers |
| Sterculiaceae | *Cola acuminata* | Nuts |
| Tropaeolaceae | *Trapaeolum majus* | Whole plant |
| *Hypertension* | | |
| Acanthaceae | *Acanthus montanus* | Roots |
| | *Justicia secunda* | Leaves |
| Anacardiaceae | *Lannea welwitshii* | Bark |
| Arecaceae | *Hyphaene thebaica* | Fruits |
| Asteraceae | *Acmela caulirhiza* | Leaves |
| | *Artemesia annua* | Whole plant |
| | *Crassocephalum crepidioides* | Flowers, leaves |
| | *Emilia coccinea* | Leaves |
| | *Erigeron floribundus* | Leaves |
| Caesalpiniaceae | *Cassia occidentalis* | Seeds, roots |
| Clusiaceae | *Garcinia kola* | Nut |
| Commelinaceae | *Palisota hirsuta* | Leaves |
| Dennstaedtiaceae | *Pteridium aquilinum* | Leaves |
| Euphorbiaceae | *Jatropha curcas* | Roots |
| | *Jatropha gossypiifolia* | Leaves, seeds |
| | *Manihot esculenta* | Leaves |
| Fabaceae | *Desmodium adcendens* | Whole plant |
| | *Guibourtia tessmanii* | Leaves, fruits |
| | *Milletia sanagana* | Roots |
| | *Senna alata* | Leaves |
| | *Senna occidentalis* | Whole plant |
| | *Vigna unguiculata* | Leaves |
| Lamiaceae | *Ocimum gratissimum* | Whole plant |
| Lauraceae | *Persea gratissima* | Leaves, bark |
| Malvaceae | *Hibiscus rosa-sinensis* | Leaves |
| Meliaceae | *Carapa procera* | Fruits |
| Mimosaceae | *Ambligonocarpus andongensis* | Seeds |
| Mirtaceae | *Eucalyptus globulus* | Leaves |
| Moraceae | *Sloetiopsis usambarensis* | Bark |
| Pinaceae | *Pinus montana* | Buds |
| Piperaceae | *Piper umbellatum* | Leaves |
| Poaceae | *Cymbopogon citratus* | Roots, leaves |
| | *Cynodon dactylon* | Bark, leaves, roots |
| | *Saccharum Officinarum* | Whole plant |
| Polypodiaceae | *Platicerium bifurcatum* | Whole plant |
| | *Platycerium stemaria* | Whole plant |
| Portulacaceae | *Portulaca oleracea* | Leafed-stems |
| Rubiaceae | *Coffea* sp. | Seeds |
| | *Diodia scandens* | Whole plant |
| | *Gardenia ternifolia* | Bark |
| | *Pausinistalia yoyimbe* | Bark |

| Families | Species | Organs Used |
|---|---|---|
| Rutaceae | *Fagara macrophylla* | Bark |
| Solanaceae | *Solanum torvum* | Fruits |
| Sterculiaceae | *Pterygota bequaertii* | Bark |
| | *Theobroma cacao* | Fruits |
| Thymeaceae | *Guiera senegalensis* | Roots, bark |
| Zingiberaceae | *Curcuma longa* | Rhizomes |

Globally, these plants are grouped into 70 families, of which 35 are represented by at least 2 species. We have in particular Fabaceas with 18 species, Asteraceae and Rubiaceae with 14 species each, Euphorbiaceae with 9 species, Apocynaceae and Meliaceae with 8 species each, Rutaceae with 7 species each, Annonaceae, Cucurbitaceae and Mimosaceae with 6 species each, Acanthaceae, Anacardiaceae, Irvingiaceae, Loranthaceae and Solanaceae with 5 species each, Clusiaceae, Malvaceae, Moraceae, Myrtaceae, Phyllanthaceae, Poaceae and Sterculiaceae with 4 species each, Asphodelaceae, Bignoniaceae and Zingiberaceae with 3 species, Arecaceae, Bombacaceae, Caesalpiniaceae, Caryophyllaceae, Convolvulaceae, Gluttiferaceae, Lauraceae, Liliaceae, Olacaceae, Polypodiaceae with 2 species each. The other 36 families are represented by a single species. Concerning usage, the whole plant is used for about 13.1% of species while for others, one or more parts/organs of plants are used. Thus, bark (from stem or roots) and leaves seems to be the most parts used (with respectively 35.6% and 34.3%) followed by roots/rhizomes/tubers (10.8%), fruits (10.3%), seeds (6.1%), flowers, nuts, bud and starch (less than 2% each).

### *5.2. Identified Agents from Studies of Biological Activities*

As presented in tables 5 to 9, about 151 studies, published from 1998 to October 2022, have been exploited to identify natural agents with activity against factors associated with MetS. These properties have been demonstrated through *In vitro* or *In vivo* studies. *In vitro* studies mainly concerned capacity to inhibited activity of some enzymes relevant to carbohydrate/lipid digestion and cardio-metabolic diseases (lipase, 3-hydroxy-3-methyl-glutaryl-coenzyme A reductase, α-amylase, β-amylase, α-glucosidase, β-glucosidase, invertase, angiotensin converting enzyme). *In vivo* studies were done with specific animal cells, animal models of diseases (mice, rats or Guinea pigs) or human subjects suffering from disease. Generally, these studies showed, in the case of obesity, the ability of natural agents to decrease or to prevent the increase of morphometric parameters (body mass, BMI…), fat deposits, lipids accumulation, tissue inflammation and food intake. As for dyslipidaemia, the studies showed the ability to decrease or to prevent the increase of triglycerides, total-cholesterol, LDL-cholesterol, atherogenic index; and to increase or to prevent the decrease of HDL-cholesterol. For diabetes insulin/resistance, studies revealed the ability of natural agents to prevent or to eliminate the insulin resistance, the destruction of pancreas cells and glucose intolerance; to decrease or to prevent the increase of glycaemia; or to increase or to prevent the decrease of glucose uptake by cells. Concerning hypertension, the studies showed the ability to decrease or to prevent the increase of blood pressure, heart rate; to increase or to prevent the decrease of vascular contraction, vasodilation, aortic relaxation, diuresis and elimination of $Na^+$, $K^+$ and $Cl^-$; and to improve endothelial function. In addition, some studies showed the other properties of natural agents in favour of metabolic syndrome particularly the ability to decrease or prevent oxidative stress, inflammation, tissue damage (kidney, liver, pancreas…), platelet aggregation or haemostatic ailments. Most of these studies have been focused on plants and only few on other resources.

#### *5.2.1. Plants Resources*

As presented in tables 5 to 8, a total of 129 plant species have been identified from. According to results obtained from the various studies, 10 species showed activity against the four factors associated with MetS and also presented other benefits (Table 5).

***Table 5.*** *Cameroonian medicinal with activities on the four factors associated to MetS.*

| Families | Species | Organs Used | Experiments | References |
|---|---|---|---|---|
| *Activities on obesity, dyslipidemia, diabetes, hypertension and with others benefits* | | | | |
| Combretaceae | *Terminalia superba* | Stem bark | Extract in the isolated aorta rings of the rat constricted | [82] |
| | | | Extract in hypertensive rats | [83, 84] |
| | | | Extract on amylase activity | [85] |
| | | | Extract in diabetic rats | [86, 87] |
| Fabaceae | *Erythrina senegalensis* | Stem bark | Extract on diabetic hypertensive rats | [88] |
| Guttiferacea | *Mammea africana* | Stem bark | Extract in hypertensive rats | [89] |
| | | | Extract in isolated aorta rings of the rat constricted | [90] |
| | | | Stem in diabetic rats | [91] |
| Lauracea | *Persea americana* | Fruit pit, Leaves, seeds | Fruit pit extract associated to *Allium sativum* in rats with MetS | [92] |
| | | | Leaves extract associated to *Cymbopogon citratus* stems, *Citrus medica* fruits and honey in hypertensive rats | [87] |
| | | | Leaves extract in diabetes rats and on *In vitro* activities of amylase and glycosidase | [93] |
| | | | Leaves extract on activities of enzymes relevant to carbohydrate/lipid digestion and cardio-metabolic diseases *In vitro* | [94] |

| Families | Species | Organs Used | Experiments | References |
|---|---|---|---|---|
| Mimosaceae | *Dichrostachys glomerata* | Fruits pod | Extract in obese human subjects | [95] |
| | | | Extract in obese and diabetic human subjects | [96] |
| | | | Powder on *In vitro* lipase activities and in rats in high fat diet | [97] |
| | | | Extract on activities of enzymes relevant to carbohydrate/lipid digestion and cardio-metabolic diseases *In vitro* | [98, 99] |
| | *Tetrapleura tetraptera* | Fruits, stem bark, | Extract on triglyceride accumulation glucose uptake in SW 872 human adipocytes | [100] |
| | | | Stem bark extract in obese rats | [101] |
| | | | Fruits extract in obese and diabetic rats | [102] |
| | | | Fruits extract mixed with *Aframomum citratum* on *In vitro* uptake of glucose and in diabetes rats | [103] |
| | | | Fruits extract on *In vitro* activities of enzymes relevant to carbohydrate/lipid digestion and cardio-metabolic diseases | [99] |
| | | | Fruits extract on triglyceride accumulation glucose uptake in SW 872 human adipocytes | [100] |
| | | | Fruits extract on *In vitro* amylase and lipase activities | [98] |
| Poaceae | *Cymbopogon citratus* | Aerial part, stem | Aerial part extract associated to *Bidens pilosa in* hypertensive rats | [104] |
| | | | Stem extract associated to *Persea Americana*, *Citrus medica* and honey in hypertensive rats | [87] |
| Rutaceae | *Citrus medical* | Fruits | Extract associated to *Persea Americana*, *Cymbopogon citratus* and honey in hypertensive rats | [87] |
| Sapotacae | *Baillonella toxisperma* | Stem bark | Extract in diabetic rats | [105] |
| Zingiberaceae | *Aframomum citratum* | Seeds | Extract mixed with *Tetrapleura tetraptera* on *In vitro* uptake of glucose and in diabetes rats | [103] |
| | | | Extract on *In vitro* activities of enzymes relevant to carbohydrate/lipid digestion and cardio-metabolic diseases | [98, 99, 106] |
| | | | Extract on triglyceride accumulation glucose uptake in SW 872 human adipocytes | [100] |

Atotal of 53 species showed activities against 3 factors (Table 6) among which 35 species on obesity, dyslipidemia, diabetes and with others benefits; nine activities on obesity, dyslipidemia, hypertension and with others benefits; and nine on obesity, dyslipidemia and diabetes.

***Table 6.*** *Cameroonian medicinal with activities on three factors associated to MetS.*

| Families | Species | Organs Used | Experiment | References |
|---|---|---|---|---|
| *Activities on obesity, dyslipidemia, diabetes* and *with others benefits* | | | | |
| Anacardiaceae | *Anacardium occidentale* | Leaves, seeds, bark, apple | Leaves extract and fractions in diabetic rats | [107] |
| | | | Extract of seeds, leaves, bark and apple on differentiated C2C12 myoblasts and rat liver mitochondria | [108] |
| | | | Leaves extract in diabetic rats | [109, 110] |
| Asteraceae | *Sclerocarya birrea* | Stem bark | Extract on diabetic rats | [111] |
| | *Ageratum conyzoides* | Leaves | Extract and fractions in diabetic rats | [112-114] |
| | *Emilia coccinea* | Leaves | Extract in diabetic rats | [115] |
| | *Spilanthes africana* | Leaves | Extract associated with *Portulaca oleracea* and *Sida rhombifolia* in diabetes rats | [116] |
| Bombacaceae | *Ceiba pentandra* | Stem bark | Extract in skeletal muscles and liver slices | [117] |
| | | | Extract in *In vitro* alpha-amylase and alpha-glucosidase activities | [118] |
| | | | Extract on diabetic rats | [119, 120] |
| Burseraceae | *Canarium schweinfurthii* | Stem bark | Extract in diabetes rats | [86, 121] |
| Fabaceae | *Vigna unguiculata* | Seeds | Biscuit from seeds flour associated to *Musa sapientum* in diabetic rats | [122] |
| Irvingiaceae | *Irvingia gabonensis* | Seeds | Extract in normal Guinea pig | [123] |
| | | | Powder in obese human subjects | [124] |
| | | | Extract and different fraction on *In vitro* glucose uptake and in normal rats | [125] |
| | | | Extract on murine 3T3-L1 adipocytes | [126] |
| | | | Extract associated with *Cissus quadrangularis* in obese human subjects | [127] |
| | | | Powder in diabetic rats | [128] |
| | | | Mucilage from seeds on rats under high fat diet | [129] |
| Lamiaceae | *Irvingia wombolu* | Fruits | Extract in diabetic rats | [130] |
| | *Clerodendrum thomsoniae* | Leaves | Extract in rats under high fat diet | [131] |
| | *Mentha spicata* | Leaves | Extract in rats under high fat diet | [132] |
| Laurenthaceae | *Phragmanthera capitata* | Leaves | Extract on diabetic rats | [133] |
| | *Pterocarpus soyauxii* | Stem bark | Stem bark extracts in diabetic rats | [134] |
| Liliaceae | *Allium sativum* | Bulbs | Extract associated with *Persea Americana* pit in rats with MetS | [92] |
| Loranthaceae | *Phragmanthera capitata* | Whole plant | Extract in diabetic rats | [135, 136] |
| Malvaceae | *Abelmoschus esculentus* | Fruits, seeds | Flours from fruits and seeds on diabetics rats | [137] |
| | *Hibiscus sabdariffa* | Calyces | Extract in rats under high fat diet | [132] |
| | *Sida rhombifolia* | Leaves | Extracts associated with *Portulaca oleracea* and *Spilanthes africana* in | [116] |

| Families | Species | Organs Used | Experiment | References |
|---|---|---|---|---|
| | | | diabetes rats | |
| Melianthaceae | *Bersama engleriana* | Leaves | Extract in diabetic rats | [138, 139] |
| Moraceae | *Dorstenia picta* | Twigs | Extract in diabetic rats | [140] |
| | *Ficus vallis-choudae* | Leaves | Extract in diabetic and obese rats | [141] |
| Musaceae | *Musa sapientum 'banane cochon'* | Fruits | Formulated biscuit in normal human subjects or formulated biscuit in association with *Vigna unguiculata* in diabetic rats | [122, 142] |
| Piperaceae | *Piper nigrum* | Leaves | Extract in rats under high fat diet | [143] |
| Portulacaceae | *Portulaca oleracea* | Leaves | Extracts associated with *Spilanthes africana* and *Sida rhombifolia* in diabetes rats | [116] |
| Rubiaceae | *Morinda lucida* | Stem bark | Extract in diabetic rats | [141, 144] |
| Rutaceae | *Fagara tessmannii* | Stem | Extract in obese rats | [145] |
| Sapotaceae | *Vitellaria paradoxa* | Bark | Extract in diabetic rats or in diabetic and obese rats | [146, 147] |
| Solanaceae | *Physalis peruviana* | Leaves | Extract and fractions in diabetics rats | [148, 149] |
| Tiliaceae | *Glyphaea brevis* | Leaves | Leaves extracts of *G.* in dyslipidemic and diabetic rats | [150] |
| Urticaceae | *Laportea ovalifolia* | Aerial part | Extract from aerial part on amylase activity or in diabetic rats | [85, 151] |
| Verbenaceae | *Clerodendrum thomsoniae* | Leaves | Extract in rats under high fat diet | [152] |
| Vitaceae | *Cissus polyantha* | Leafy stems, leaves | Leafy stems extract on *In vitro* amylase glucosidase activities and in diabetic rats | [153] |
| | | | Leaves extract from in diabetic rats | [154] |
| | *Cissus quadrangularis* | Leaves and stem | Leaves extract (Cylaris™) in obese human subjects | [155] |
| | | | Leaves extract (CQR-300) and formulation in obese human subjects | [156] |
| | | | Extract associated with *Irvingia gabonensis* in obese human subjects | [127] |
| | | | Leaves and stem extract in obese human subjects | [157] |
| Zingiberaceae | *Zingiber officinale* | Rhizomes | Extract in rats under high fat diet | [132] |
| *Activities on obesity, dyslipidemia, hypertension and with others benefits* | | | | |
| Bombacaceae | *Adansonia digitata* | | Extract from stem bark in hypertensive rats | [158] |
| Clusiaceae | *Allablanckia floribunda* | Bark | Extract in hypertensive rats | [159, 160] |
| | *Garcinia lucida* | | Extract in hypertensive rats | [161] |
| Annonaceae | *Monodora myristica* | Seeds, roots | Extract in *In vitro* activities of enzymes relevant to carbohydrate/lipid digestion and cardio-metabolic diseases | [98, 99] |
| | | | Extract on triglyceride accumulation and glucose uptake in SW 872 human adipocytes | [100] |
| | *Xylopia aethiopica* | Fruits | Extract on *In vitro* activities of enzymes relevant to carbohydrate/lipid digestion and cardio-metabolic diseases | [98, 99] |
| | | | Extract on triglyceride accumulation glucose uptake in SW 872 human adipocytes | [100] |
| | *Xylopia parviflora* | Seeds/fruits | Extract on *In vitro* activities of enzymes relevant to carbohydrate/lipid digestion and cardio-metabolic diseases | [98, 99] |
| | | | Extract on triglyceride accumulation glucose uptake in SW 872 human adipocytes | [100] |
| Asteraceae | *Echinops giganteus* | Roots | Extract on *In vitro* activities of enzymes relevant to carbohydrate/lipid digestion and cardio-metabolic diseases | [98, 99] |
| | | | Extract on triglyceride accumulation glucose uptake in SW 872 human adipocytes | [100] |
| Huaceae | *Afrostyrax lepidophyllus* | Seeds, roots | Extract on *In vitro* activities of enzymes relevant to carbohydrate/lipid digestion and cardio-metabolic diseases | [98, 99] |
| | | | Extract on triglyceride accumulation glucose uptake in SW 872 human adipocytes | [100] |
| Zingiberaceae | *Aframomum melegueta* | Seeds, roots | Extract on *In vitro* activities of enzymes relevant to carbohydrate/lipid digestion and cardio-metabolic diseases | [98, 99] |
| | | | Extract on triglyceride accumulation glucose uptake in SW 872 human adipocytes | [100] |
| *Activities on obesity, dyslipidemia and diabetes* | | | | |
| Bromeliacea | *Ananas comosus* | Fruits | Juice in obese rats | [162] |
| Caricaceae | *Carica papaya* | Fruits | Juice in obese and diabetic rats | [163] |
| Combretaceae | *Combretum molle* | Twigs | Extract on diabetic rats | [164] |
| | *Terminalia glaucescens* | Leaves | Extract on diabetic mice | [165] |
| Fabaceae | *Glycine max* | Seeds | Powder in rats under high fat high sucrose diet | [166] |
| Meliaceae | *Azadirachta indica* | Seeds | Oil in diabetic rats | [167] |
| Moringaceae | *Moringa oleifera* | Leaves (Afya tea®) | Extract on diabetic rats | [168] |
| Zingiberaceae | *Aframomum daniellii* | Seeds | Extract from fruits on *In vitro* amylase, invertase and lipase activities | [98, 106] |
| | *Aframomum aulacocarpus* | Seeds | | |

Table 7 showed that 20 species have an activity against two factors associated to MetS among which five on obesity and dyslipidemia with others benefits; one on obesity and hypertension with others benefits; two on obesity and diabetes; six on dyslipidemia and diabetes with others benefits; five on dyslipidemia and hypertension with others benefits; and one on

dyslipidemia and hypertension.

***Table 7.*** *Cameroonian medicinal with activities on two factors associated to MetS.*

| Families | Species | Organs Used | Experiment | References |
|---|---|---|---|---|
| *Activities on obesity and dyslipidemia with others benefits* | | | | |
| Convolvulaceae | *Ipomoea batatas* | Leaves | Powder in rats under high fat diet | [169] |
| Cucurbitaceae | *Momordica foetida* | Roots, stem, leaves | Extract of mixture in obese rats | [170] |
| Fabaceae | *Guibourtia tessmannii* | Bark | Extract in rats under high fat diet | [171] |
| Lauraceae | *Beilschmedia obscura* | Seeds | Powder in rats under high fat/high sucrose diet | [172] |
| Moraceae | *Ficus glumosa* | Leaves | Extract in rats under high-cholesterol diet | [173] |
| *Activities on obesity and hypertension with others benefits* | | | | |
| Crassulaceae | *Kalanchoe pinnata* | Leaves | Extract in high salt-loaded rats | [174] |
| *Activities on obesity and diabetes* | | | | |
| Crassulaceae | *Kalanchoe crenata* | Leaves | Extract in diabetic rats | [175] |
| Solanaceae | *Solanum aethiopicum* | Leaves | Extracts in diabetes rats | [176] |
| *Activities on dyslipidemia and diabetes with others benefits* | | | | |
| Annonaceae | *Annona muricata* | Leaves | Extract in diabetes rats | [177] |
| Apocynaceae | *Alstonia boonei* | Stem bark | Extract in diabetic rats | [178] |
| | *Millettia laurentii* | Bark | Extract in diabetic rats | [179] |
| Fabaceae | *Scorodophloeus zenkeri* | Bark, roots, seeds | Extract in *In vitro* activities of enzymes relevant to carbohydrate/lipid digestion and cardio-metabolic diseases | [98, 99] |
| | | | Extract on triglyceride accumulation glucose uptake in SW 872 human adipocytes | [100] |
| Thymeaceae | *Guiera senegalensis* | Roots | Extract on diabetic rats | [180] |
| Tiliaceae | *Triumphetta cordifolia* | Bark | Mucilage on rats under high fat diet | [129] |
| *Activities on dyslipidemia and hypertension with others benefits* | | | | |
| Asteraceae | *Bidens pilosa* | Whole plant | Extracts from whole plant in hypertensive rats | [160, 181] |
| | | | Extract associated to *Cymbopogon citratus* in hypertensive rats | [104] |
| Menispermaceae | *Jateorhiza macrantha* | Leaves | Extract in hypertensive rats | [182] |
| Poaceae | *Leersia hexandra* | Whole plant | Extract in hypertensive rats | [183] |
| Rutaceae | *Zanthoxylum leprieurii* | Seeds | Extract on *In vitro* activities of enzymes relevant to carbohydrate/lipid digestion and cardio-metabolic diseases | [99] |
| | | | Extract on triglyceride accumulation glucose uptake in SW 872 human adipocytes | [100] |
| Verbenaceae | *Vitex cienkowskii* | Stem-bark | Extract in hypertensive rats | [184] |
| *Activities on dyslipidemia and hypertension* | | | | |
| Lauraceae | *Cinnamomum zeylanicum* | Stem bark | Extract in hypertensive rats | [185, 186] |
| | | | Extract in isolated aorta rings of the rat constricted | [187] |

A total of 46 species showed an activity against only one factor associated with MetS (Table 8) of which four on dyslipidemia with other benefits; 32 on dyslipidaemia and 10 on hypertension.

***Table 8.*** *Cameroonian medicinal with activities on one factor associated to MetS.*

| Families | Species | Organs Used | Experiment | References |
|---|---|---|---|---|
| *Activities on dyslipidemia with others benefits* | | | | |
| Caesalpiniaceae | *Cassia occidentalis* | Leaves | Extract in rats with hypercholesterolemia | [188] |
| Euphorbiaceae | *Ricinodendron heutelotii* *Tetracarpidium conophorum* | Seeds | Oil in normal rats | [189] |
| *Activities on dyslipidemia* | | | | |
| Cyperaceae | *Scleria striatum* | Roots | Extract on *In vitro* amylase and lipase activities | [98] |
| *Activities on diabetes with others benefits* | | | | |
| Amaryllidaceae | *Crinum jagus* | Whole plant | Extract on diabetic rats | [190] |
| | *Catharentus roseus* | Leaves | Extract in diabetes rats and on *In vitro* activities of amylase and glycosidase | [93] |
| Apocynaceae | *Gymnema sylvestre* | Leaves | Extract and fractions on diabetics rats | [191] |
| | *Picralima nitida* | Stem bark and leaves | Extract in diabetes mice | [192] |
| Asteraceae | *Sonchus oleraceus* | Whole plant | Extract in diabetes mice | [192] |

| Families | Species | Organs Used | Experiment | References |
|---|---|---|---|---|
| Cecropiaceae | *Musanga cecropioides* | Stem bark | Extract on diabetic rats | [193] |
| Costaceae | *Costus afer* | Whole plant | Extract of whole plant on digestive enzyme or in diabetic rats | [194] |
| Cucurbitaceae | *Luffa aegyptiaca* | Whole plant | Extract on amylase activity | [85] |
| Euphorbiaceae | *Bridelia atroviridis* | Bark | Extract in diabetic rats | [196] |
| Mirtaceae | *Eucalyptus globulus* | Leaves | Extract in diabetes rats and on *In vitro* activities of amylase and glycosidase | [93] |
| Rubiaceae | *Nauclea pobeguinii* | Stem-bark | Extract on diabetic mice | [197] |
| Sapotacae | *Gambeya africana* | Pulp | Extract in diabetics rats | [198] |
| Sterculiaceae | *Cola nitida* | Leaves, nuts | Extract on amylase activity | [85] |
| Verbenaceae | *Vitex thyrsiflora* | Leaves | Extract on diabetic rats | [199] |
| *Activities on diabetes* | | | | |
| Asteraceae | *Vernonia amygdalina* | Leaves and roots | Extract on glucosidase activity and protein glycation | [200] |
| Cucurbitaceae | *Cucurbita moschata* | Seeds | Globulins extracted on diabetic rats | [201] |
| | *Citrullus lanatus* | Seeds | Globulins extracted on diabetic rats | |
| | *Lagenaria siceraria* | Seeds | Globulins extracted on diabetic rats | |
| | *Telfairia occidentalis* | Seeds | Globulins extracted on diabetic rats | |
| | | Leaves | Extract of on diabetic rats and on *In vitro* activity of amylase | [202] |
| Euphorbiaceae | *Bridelia ndellensis* | Stem bark | Extract and fractions on diabetic rats | [203] |
| Hypericaceae | *Harungana madagascarensis* | Stem bark | Extract on amylase activity | [85] |
| Lauraceae | *Hypodaphnis zenkeri* | Bark | Extract on *In vitro* amylase and lipase activities | [98] |
| Mimosaceae | *Albizia sp* | Bark | Extract on amylase activity | [85] |
| | *Pentaclethra macrophylla* | Sterm bark | Extract in rats and on *In vitro* activity of amylase | [204] |
| Moraceae | *Dorstenia psilurus* | Roots | Extract from roots on *In vitro* amylase and lipase activities | [98] |
| Piperaceae | *Piper umbellatum* | Leaves | Extract in *In vitro* activities of enzymes relevant to carbohydrate/lipid digestion and cardio-metabolic diseases | [94] |
| Rubiaceae | *Rytigynia senegalensis* | Leaves | Extract in amylase and glucosidase activities | [205] |
| Rutaceae | *Fagara leprieurii* | Seeds | Extract on *In vitro* amylase and lipase activities | [98] |
| | *Fagara xanthoxyloide* | Seeds | Extract on *In vitro* amylase and lipase activities | |
| Solanaceae | *Solanum melongena* | Fruits | Extract on *In vitro* amylase and lipase activities | [98] |
| Sterculiaceae | *Cola odorata* | Nuts | Extract on amylase activity | [85] |
| Ulmaceae | *Trema orientalis* | Stem bark | Extract in diabetic rats | [206] |
| *Activities on hypertension with others benefits* | | | | |
| Amaryllidacea | *Crinum zeylanicum* | Leaves | Extract and fractions in hypertensive rats | [90, 207] |
| Menispermaceae | *Stephania abyssinica* | Leaves | Extract on isolated aorta rings of the rat constricted and in hypertensive rats | [208, 209] |
| Rutaceae | *Vepris heterophylla* | Leaves | Extract on normal rats | [210] |
| Solanaceae | *Solanum torvum* | Fruits | Extract in isolated aorta rings of the rat constricted and in hypertensive rats | [211, 212] |
| *Activities on hypertension* | | | | |
| Acanthaceae | *Brillantaisia nitens* | Leaves | Extract in hypertensive rats | [213, 214] |
| Crassulaceae | *Kalanchoe pinnata* | Leaves | Extract in hypertensive rats | [215] |
| Fabaceae | *Erythrina indica* | Stem bark | Extract in hypertensive rats | [216] |
| Malvaceae | *Eribroma oblongum* | Stem bark | Extract in normal rats | [217] |
| Rubiaceae | *Mitragyna ciliata* | Stem bark | Extract in isolated aorta rings of the rat and Guinea pig constricted | [218] |
| Rutaceae | *Zanthoxylum heitzii* | Stem bark | Extract in isolated aorta rings of the rat constricted | [173] |

Globally, these 129 plant species belonged to 54 families from which Asteraceae, Fabaceae and Rutaceae are the most represented with seven species each. They were followed by Cucurbitaceae with 6 species, Zingiberaceae with 5 species and by Annonaceae, Apocynaceae, Euphorbiaceae, Lauracea, Malvaceae, Mimosaceae, Moraceae, Rubiaceae and Solanaceae with 4 species each. Combretaceae, Crassulaceae, Sapotacae and Verbenaceae were represented by 3 species each. Those represented by 02 species were Amaryllidaceae, Anacardiaceae, Bombacaceae, Clusiaceae, Irvingiaceae, Lamiaceae, Laurenthaceae, Menispermaceae, Piperaceae, Poaceae, Sterculiaceae, Tiliaceae and Vitaceae. The families represented by only one species were Acanthaceae, Bromeliaceae, Burseraceae, Caesalpiniaceae, Caricaceae, Cecropiaceae, Convolvulaceae, Costaceae, Cyperaceae, Guttiferaceae, Huaceae, Hypericaceae, Liliaceae, Loranthaceae, Meliaceae, Melianthaceae, Mirtaceae, Moringaceae, Musaceae, Portulacaceae, Thymeaceae, Ulmaceae and Urticaceae. The plants were mostly tested alone or sometimes associated with one or two other plant extracts. Concerning used parts, the whole plant (9) is used for about 7.0% of species while for others, one or more parts/organs of plants that are used. Thus, leaves, bark (from stem or roots) and seeds seems to be the most parts used (with respectively 33.6%, 26.6% and 18.8%) followed by fruits (10.2%), roots/rhizomes (10.2%), flowers, nuts and bud (less than 2% each). The forms of plants used were mostly extracts with various solvents, alone or combined, such as water, ethanol, methanol, methylene chloride and hexane. The other forms of powder, juice and oil were also tested. On noted that from these 129 plant species, 54 species were also identified in ethnomedicinal and ethnobotanic studies

presented above.

### *5.2.2. Other Resources*

Apart from the panoply of Cameroonian plant resources with activities on at least one factor associated with MetS, studies have shown the activities of others resources especially marine products (fishes and algae), insects, mushrooms and probiotics as shown in table 9. Fishes are represented by eight species belonging to eight families and the parts tested were oil and flesh [17, 21-222]. One species (*Ilisha Africana*) showed activity against obesity, dyslipidemia and diabetes and presented others benefits, two species (*Ethmalosa fimbriata* and *Pseudotolithus senegalensis*) presented activity on obesity and dyslipidemia while five species (*Chrysicthys nigrodigitatus*, *Cyprinus carpio*, *Heterotis niloticus*, *Oreochromis niloticus* and *Silurus glanis*) were active against dyslipidaemia. As for algae, only one species (*Aphanizomenon flosaquae*) was studied and their extract showed activity against the four factors associated with MetS and presented also others benefits [223]. Concerning insects, only two species were studied [224] and their oil showed activity against obesity, dyslipidemia and presented others benefits for *Brachytrupes membranaceus* and against obesity and presented others benefits for *Rhynchophorus phoenicis*. For mushrooms, 11 species grouped in three families (Ganodermataceae, Pleurotaceae and Pleurotaceae) have been studied [225-231] and the results showed that their extracts or polysaccharides have activity against obesity, dyslipidemia and presented others benefits for one species; against dyslipidemia, diabetes and presented others benefits for three species; or against dyslipidemia and diabetes for seven species. As for probiotics, four species of belonging to Lactobacillaceae family were studied [232-234] and they showed activity against obesity, diabetes and presented others benefits for one species; or against obesity and dyslipidemia for three species.

***Table 9.*** *Others natural resources with activities on factors associated to MetS.*

| Families | Species | Experiment | References |
|---|---|---|---|
| MARINE PRODUCTS | | | |
| Fishes | | | |
| *Activities on obesity, dyslipidemia, diabetes and with others benefits* | | | |
| Pristigasteridae | *Ilisha africana* | Oil from fish flesh in rats under high fat diet | [220] |
| *Activities on obesity and dyslipidemia* | | | |
| Clupeidae | *Ethmalosa fimbriata* | Oil from fish flesh in obese rats | [221] |
| Sciaenidae | *Pseudotolithus senegalensis* | | [17] |
| *Activities on dyslipidemia* | | | |
| Cichlidae | *Oreochromis niloticus* | | |
| Cyprinidae | *Cyprinus carpio* | Fish flesh in normal rats | [219] |
| Osteoglossidae | *Heterotis niloticus* | | |
| Siluridae | *Silurus glanis* | | |
| Claroteida | *Chrysicthys nigrodigitatus* | Fish flesh in rats infected with *Salmonella typhi* | [222] |
| Algea | | | |
| *Activities on obesity, dyslipidemia, diabetes, hypertension and with others benefits* | | | |
| *Aphanizomenonaceae* | *Aphanizomenon flosaquae* | Extract blended with of plant-based polysaccharides, esterified fatty acids, pomegranate, polyphenols and ellagic acid, beta carotene (LeptiCore®) in obese human subjects | [223] |
| INSECTS | | | |
| *Activities on obesity, dyslipidemia and with others benefits* | | | |
| Gryllidae | *Brachytrupes membranaceus* | Oil from insects in rats under high fat diet | [224] |
| *Activities on obesity and with others benefits* | | | |
| Curculionidae | *Rhynchophorus phoenicis* | Oil from larvae in rats under high fat diet | [224] |
| MUSHROOMS | | | |
| *Activities on obesity, dyslipidemia and with others benefits* | | | |
| Ganodermataceae | *Ganoderma applanatum* | Polysaccharides extract on obese rats | [225] |
| *Activities on dyslipidemia, diabetes and with others benefits* | | | |
| Pleurotaceae | *Pleurotus floridanus / P. pulmonarius / P sajor-caju* | Extracts from each species or from mixture in diabetic rats, rats fed with glucose, stressed rats, or in *In vitro* activities of amylase | [226-228, 230, 231] |
| *Activities on dyslipidemia and diabetes* | | | |
| Lyophyllaceae | *Termitomyces letestui / T. microcarpus / T. schimperi / T. aurantiacus / T. clypeatus / T. umkowaan* | Extract on *In vitro* activities of α-amylase, β-glucosidase, invertase and lipase | [232] |
| PROBIOTICS | | | |
| *Activities on obesity, diabetes and with others benefits* | | | |
| Lactobacillaceae | *Lactobacillus fermentum* PRI 29 | Strain tested in diabetic mice | [233] |
| *Activities on obesity and dyslipidemia* | | | |
| Lactobacillaceae | *L. plantarum* 29V | Strain associated to honey in rats under high fat diet | [233] |
| | *L. plantarum* Lp10S / *L. plantarum* Lp11S | Strains tested *In vitro* for their capability to remove cholesterol and *In vivo* in rabbits under high fat diet | [234] |

# 6. Conclusion

The main objective of the present review was to identify from existing literature, the natural agents found in Cameroon useful in the management of MetS and factors associated. First and foremost, an overview of MetS was provided, including their definition, pathophysiology, epidemiology and management. We noted according to existing data that the prevalence of MetS in Cameroon varies from 7.0 to 41.1% according to the area and period of study and to the concerned specific groups. It is the same for the associated factors with a prevalence of 8.0 to 69.1% for obesity and overweight; 3.4 to 75.4% for dyslipidaemia; 4.8 to 20.5% for diabetes; and 4.1 to 46.5% for hypertension. Also, existing data shows that several kinds of resources are used in the management of at least one factor associated with MetS in particular plants, marine products, insects, mushrooms and probiotics. Plants are by far the most represented with about 288 species of which 159 species were identified from ethnomedicinal and ethnobotanical studies, 75 species identified from studies on biological properties and 54 from both types of studies. Other resources are only identified from study of biological properties. Marine products are represented by fishes (eight species) and algae (one species) while insects are presented with two species, mushrooms with 11 species and probiotics with two species.

# Data Availability

The data used in this study are available from the corresponding authors upon request.

# Conflicts of Interest

The authors declare that there is no conflict of interest regarding the publication of this article.

# Funding Statement

This study did not receive any funding in any form.

# References

[1] Fahed, G., Aoun, L., Bou Z. M., Allam, S., Bou Z. M., Bouferraa, Y. and Assi, H. I. (2022). Metabolic syndrome: Updates on pathophysiology and management in (2021). *International Journal of Molecular Sciences 23* (2): 786. doi: 10.3390/ijms23020786.

[2] Starzak, M.; Stanek, A.; Jakubiak, G. K.; Cholewka, A.; Cieślar, G. (2022). Arterial Stiffness Assessment by Pulse Wave Velocity in Patients with Metabolic Syndrome and Its Components: Is It a Useful Tool in Clinical Practice? International Journal of Environmental Research and Public Health 19: 10368. doi: 10.3390/ijerph191610368.

[3] Shiomi N. (2022). Introductory Chapter: An Overview of metabolic syndrome and its prevention. In (Ed.). In lifestyle-related diseases and metabolic syndrome. *IntechOpen*. doi: 10.5772/intechopen.108025.

[4] Rochlani Y., Pothineni N. V., Kovelamudi S. and Mehta, J. L. (2017). Metabolic syndrome: pathophysiology, management and modulation by natural compounds. *Therapeutic advances in cardiovascular disease* 11 (8): 215-225. doi: 10.1177/175394471771137.

[5] Jaspinder K. (2014). A comprehensive review on metabolic syndrome. *Cardiology research and practice* 2014: 943162. doi: 10.1155/2014/943162.

[6] Belete, R., Ataro, Z., Abdu, A. and Sheleme, M. (2021). Global prevalence of metabolic syndrome among patients with type I diabetes mellitus: a systematic review and meta-analysis. *Diabetology and Metabolic Syndryndrome* 13 (1): 25. doi: 10.1186/s13098-021-00641-8.

[7] Faijer-Westerink, H. J., Kengne, A. P., Meeks, K. A. and Agyemang, C. (2020). Prevalence of metabolic syndrome in sub-Saharan Africa: A systematic review and meta-analysis. *Nutrition, Metabolism and Cardiovascular Diseases 30* (4): 547-565. doi: 10.1016/j.numecd.2019.12.012.

[8] Swarup S., Goyal A., Grigorova Y. and Zeltser R. (2022). Metabolic syndrome. [Updated 2022 Oct 24]. In: StatPearls [Internet]. Treasure Island (FL): StatPearls Publishing; 2022 Jan. Available from: https: //www.ncbi.nlm.nih.gov/books/NBK459248/

[9] Klaschka, U. (2015). Naturally toxic: natural substances used in personal care products. *Environmental Sciences Europe 27* (1). doi: 10.1186/s12302-014-0033-2.

[10] Noce A., Di Lauro M., Di Daniele F., Pietroboni Z. A., Marrone G., Borboni P., Di Daniele N. (2021). Natural bioactive compounds useful in clinical management of metabolic syndrome. *Nutrients* 13 (2). doi: 10.3390/nu13020630.

[11] Panahi Y., Hosseini M. S., Khalili N., Naimi E., Simental-Mendía L. E., Majeed M. and Sahebkar A. (2016). Effects of curcumin on serum cytokine concentrations in subjects with metabolic syndrome: A post-hoc analysis of a randomized controlled trial. *Biomedicine and pharmacotherapy*, 82: 578-582. doi: 10.1016/j.biopha.2016.05.037.

[12] Panahi Y., Khalili N., Hosseini M. S., Abbasinazari M. and Sahebkar A. (2014). Lipid-modifying effects of adjunctive therapy with curcuminoids–piperine combination in patients with metabolic syndrome: results of a randomized controlled trial. *Complementary therapies in medicine 22* (5): 851-857. doi: 10.1016/j.ctim.2014.07.006.

[13] Yusni, Y. and Meutia, F. (2020). Action mechanism of Rosella (Hibiscus sabdariffa L.) used to treat metabolic syndrome in elderly women. *Evidence-Based Complementary and Alternative Medicine* 2020: 5351318. doi: 10.1155/2020/5351318.

[14] Gumbarewicz E., Jarząb A., Stepulak A., Kukula-Koch, W. (2022). *Zingiber officinale* Rosc. in the treatment of metabolic syndrome disorders—A Review of In Vivo Studies. *International Journal of Molecular Sciences*, 23: 15545. doi: 10.3390/ijms232415545.

[15] Francini-Pesenti F., Spinella P. and Calò L. A. (2019). Potential role of phytochemicals in metabolic syndrome prevention and therapy. *Diabetes, Metabolic Syndrome and Obesity*, 1 (12): 1987-2002. doi: 10.2147/DMSO.S214550.

[16] Lottenberg A. M., da Silva A. M., Lavrador M. S. F., Machado R. M. and Nakandakare E. R. (2012). The role of dietary fatty acids in the pathology of metabolic syndrome. *The Journal of nutritional biochemistry*, 23 (9): 1027-1040. doi: 10.1016/j.jnutbio.2012.03.004.

[17] Njinkoue J. M., Koule J. M., Tchoumbougnang F., Milong M. C., Tchintchui N. C., Fowe C. R., Schweigert F. J. and Gouado, I. (2017). Evaluation of hypolipidemic effects of oil extracted of fish *Pseudotolithus senegalensis* on dyslipidemic female rats. *International Journal of Biological and Chemical Sciences*, 11 (6): 2952-2961. https: //dx.doi.org/10.4314/ijbcs.v11i6.31

[18] Lemogoum D., Bayauli P., Toto M. J., van de Borne P., M'Buyamba-Kayamba J. R., Leeman M., Degaute J. P. and M'Buyamba-Kabangu J. R. (2010). Gender difference in the burden of cardiovascular risk factors among rural and urban adult Cameroonian populations. Results from the vitaraa study: PP.7.284. *Journal of Hypertension* 28: 134-135. doi: 10.1097/01.hjh.0000378608.81579.a7.

[19] Mfeukeu-Kuaté L., Jingi A., Boombhi J., Yonta E., Noubiap J., Hamadou B., Nganou-Gnindjio C., Nkoke C., Amougou S. N., Tankeu A., Ménanga A., Sobngwi E., Kingue S. (2018). Prevalence of metabolic syndrome and cardiovascular risk profile in Cameroon: A crosssectional study in a sub-saharan African (SSA) Setting. *EC Cardiology* 5.8: 596-605.

[20] Marbou WJT, Kuete V. (2019). Prevalence of metabolic syndrome and its components in Bamboutos Division's adults, West Region of Cameroon. *BioMed Research International*, 9. doi: 10.1155/2019/9676984.

[21] Djeufouata J. D., Ojong E. W., Njamen N. T., Assob J. C. and Telefo P. B. (2020). Prevalence and risk factors of metabolic syndrome in pregnant women in the centre and littoral regions of Cameroon. *European Journal of Clinical and Biomedical Sciences* 6 (5): 104-115. doi: 10.11648/j.ejcbs.20200605.16.

[22] Dabou S., Ongbayokolak N. S., Fonkeng S. L., Matene F. E., Kamdom N. M., Telefo P. B. (2022). Metabolic syndrome during pregnancy: prevalence and determinants among pregnant women followed-up at the Dschang District Hospital, West Region of Cameroon. *Diabetes, Metabolic Syndrome and Obesity*, 5 (15): 743-753. doi: 10.2147/DMSO.S348040.

[23] FAO, IFAD, UNICEF, WFP and WHO (2020). *The state of food security and nutrition in the world 2020: transforming food systems affordable healthy diets*. Rome, FAO, 2020, 240 pages. http: //www.fao.org/3/ca9692en/CA9692EN.pdf

[24] Fouedjeu W. P. C. Oben J. E. and Cianflone K. (2013). Prevalence of overweight, obesity and thinness in Cameroon urban children and adolescents. *Journal of Obesity*, 2013: 737592. doi: 10.1155/2013/737592.

[25] Tchoubi S., Sobngwi-Tambekou J., Noubiap J. 0. J. N, Asangbeh S. L., Nkoum B. A., Sobngwi E. (2015). Prevalence and risk factors of overweight and obesity among children aged 6–59 months in Cameroon: A multistage, stratified cluster sampling nationwide survey. *PLoS* ONE 10 (12): e0143215 doi: 10.1371/journal.pone.0143215.

[26] Engle-Stone, R., Nankap, M., Ndjebayi, A. O., Friedman, A., Tarini, A., Brown, K. H. and Kaiser, L. (2018). Prevalence and predictors of overweight and obesity among Cameroonian women in a national survey and relationships with waist circumference and inflammation in Yaoundé and Douala. *Maternal and child nutrition* 14 (4): e12648. doi: 10.1111/mcn.12648.

[27] Nyangono C. F. N., Dakam W., Ntentie F. R., Missia N., Nika J., Mbemene M. N., Ngondi L. J. and Oben J. E. (2020). Profile of Obesity and Factors Associated Among Adults Cameroonian Living in Urban Area: A Cross Sectional Study. *African Journal of Public Health* 6 (5): 256-267. doi: 10.11648/j.cajph.20200605.14.

[28] Simo L. P., Agbor V. N., Temgoua F. Z., Fozeu L. C. F., Bonghaseh D. T., Mbonda A. G. N., Yurika R., Dotse-Gborgbortsi W. and Mbanya D. (2021). Prevalence and factors associated with overweight and obesity in selected health areas in a rural health district in Cameroon: a cross-sectional analysis. *BMC public health*, 21 (1): 1-12. doi: 10.1186/s12889-021-10403-w.

[29] Nkougni J. T., Ntentie F. R., Fonkoua M., Azantsa B. G. K., Nguemto G. R. T., Lumngwena E. N., Ngondi J. L. and Oben J. E. (2022). Relationship between Adiposity, Low-Density Lipoprotein Particles Size and Cardiovascular Risk among Adult Obese Cameroonians. *Open Journal of Epidemiology*, *12* (2): 185-206. doi: 10.4236/ojepi.2022.122016.

[30] Yangoua H., Azantsa B., Kuate D., Ntentie F., Nguedjo M., Nkougni J., Tchuente B., Ngondi J. and Oben J. (2019). Characterization of Dyslipidemia and Assessment of Atherogenic Risk amongst Cameroonian Living in Yaounde: A Cross Sectional Study. *Journal of Biosciences and Medicines*, 7: 35-50. doi: 10.4236/jbm.2019.77004.

[31] Moor V. J. A., Essama D. B., Agoons B. B., Bayem J. C., Marie N. G., Jingi A. M., Nkeck J. B. and Nonga B. N. (2022). Lipid Profile abnormalities observed in obese Cameroonian adults do not depend on their bmi or abdominal circumference. *Archives of Clinical and Biomedical Research*, 6 (1): 30-40.

[32] Navti L., Niba L., Aphrodite C. and Atanga M. (2022). An Assessment of Predisposing Factors of Atherogenic Dyslipidemia in an Urban Pediatric Population in Cameroon. *Journal of Biosciences and Medicines* 10: 1-18. doi: 10.4236/jbm.2022.107001.

[33] Bigna, J. J., Nansseu, J. R., Katte, J. C. and Noubiap, J. J. (2018). Prevalence of prediabetes and diabetes mellitus among adults residing in Cameroon: a systematic review and meta-analysis. *Diabetes Research and Clinical Practice*, 137: 109-118. doi: 10.1016/j.diabres.2017.12.005.

[34] International Diabetes Federation (2021). IDF diabetes atlas. 10th ed. Brussels: International Diabetes Federation. 141 pages. https: //diabetesatlas.org/idfawp/resource-files/2021/07/IDF_Atlas_10th_Edition_2021.p

[35] Egbe T. O., Tsaku E. S., Tchounzou R. and Ngowe M. N. (2018). Prevalence and risk factors of gestational diabetes mellitus in a population of pregnant women attending three health facilities in Limbe, Cameroon: A cross-sectional study. *Pan African Medical Journal*, 31 (1). doi: 10.11604/pamj.2018.31.195.17177.

[36] Simeni N. S. R., Boombhi J., Etoa E. M. C., Tiodoung T. A., Jingi A. M., Nkem E. K., Mbono S. E. E. A, Ntsama E. M. J., Kengni K. O., Ninon T. M. A., Talbit N. S., Dehayem Y. M. and Sobngwi E. (2020). Prevalence of Diabetes and Associated Risk Factors among a Group of Prisoners in the Yaoundé Central Prison". *Journal of Diabetes Research* 2020: 5016327. doi: 10.1155/2020/5016327.

[37] Kuate D. B., Mbanya J. C., Kingue S., Tardif J. C., Choukem S. P., Perreault S., Fournier P., Ekundayo O., Potvin L., D'Antono B., Emami E., Cote R., Aubin M. J., Bouchard M., Khairy P., Rey E., Richard L., Zarowsky C., Mampuya W. M., Mbanya D., Sauvé S., Ndom P., Silva R. B. D., Assah F., Roy I. and Dubois C. A. (2019). Blood pressure and burden of hypertension in Cameroon, a microcosm of Africa: A systematic review and meta-analysis of population-based studies. *Journal of Hypertension* 37 (11): 2190-2199. doi: 10.1097/HJH.0000000000002165.

[38] Bika, L. E. C., Hermans, M. P., Bovet, P, van de Borne, P., Donnen, P., Leeman, M., Degaute, J. P., M'Buyamba-Kabangu, J. R., Hako, Y, Ndongo, A. S., Doumbe, J. N., Mbango, E., Lemogoum, D. (2020). Prevalence and determinants of blood pressure variability in pygmies of Southern region Cameroon. *Journal of Hypertension* 38 (11): 2198-2204. doi: 10.1097/HJH.0000000000002529.

[39] Nganou-Gnindjio C. N., Essama D. B., Nkeck J. R., Tchebegna P. Y., Tchatchouang K. M., Tankeu A. and Kamgno, J. (2021). Prevalence and factors associated with hypertension among school children and adolescents in urban and semi-urban areas in Cameroon. *The Journal of Clinical Hypertension 23* (8): 1490-1497. doi: 10.1111/jch.14309.

[40] Agbor, D. T. (2022). Convention on Biological Diversity Post 2020 Target: A Critical Analyses of the Threat Posed by 30 X 30 Target, Devoid of a Human Rights Approach Towards Conservation to Land Rights in Developing Countries: Case Study Cameroon. *American Journal of Environment and Climate*, 1 (2): 92-99. doi: 10.54536/ajec.v1i2.628.

[41] Dakam W., Mintom P., Mbete C. and Nyangono B. C. F. (2022). Double burden of obesity and hypertension in the elderly: Cross-sectional study of prevalence and risk factors in Foumban, West Region, Cameroon. *Journal of Food Science and Nutrition Research 5* (3): 612-621.

[42] Fokam D. K., Bita A. I. G., Dakenyo N. R. D., Agbornkwai N. A. and Negueu A. B. (2022). Obesity and high blood pressure among professional long-distance drivers in Yaoundé, Cameroon: Cross-sectional study. *Occupational Diseases and Environmental Medicine*, 10 (3): 232-254. doi: 10.4236/odem.2022.103018.

[43] Ntentie F. R., Nguedjo M. W., Mbong M. A. A., Tchuente B. R. T., Souavourbe P., Fotso H. M. T. and Oben, J. E. (2022). Prevalence of hypertension and its association with anthropometric indices among students of the University of Maroua (Far North Region, Cameroon). *Asian Journal of Medical Principles and Clinical Practice*, 5 (4): 92-102.

[44] Mayer C., Côme M., Ulmann L., Chini Zittelli G., Faraloni C., Nazih H., Ouguerram K., Chénais B., Mimouni V. (2019). Preventive effects of the marine microalga *Phaeodactylum tricornutum*, used as a food supplement, on risk factors associated with metabolic syndrome in wistar rats. *Nutrients*, 11: 1069. doi: 10.3390/nu11051069.

[45] Noubiap J. J., Nansseu J. R., Lontchi-Yimagou E., Nkeck J. R., Nyaga U. F., Ngouo A. T., Tounouga D. N., Tianyi F. L., Foka A. J. N, Ndoadoumgue A. L. i and Bigna J. J. 2022a. Global, regional and country estimates of metabolic syndrome burden in children and adolescents in 2020: a systematic review and modelling analysis. *The Lancet Child and Adolescent Health*, 6 (3): 158-170. doi: 10.1016/S2352-4642(21)00374-6.

[46] Noubiap J. J., Nansseu J. R., Lontchi-Yimagou E., Nkeck J. R., Nyaga U. F., Ngouo A. T., Tounouga D. N., Tianyi F. L., Foka A. J. N, Ndoadoumgue A. L. i and Bigna J. J. 2022. Geographic distribution of metabolic syndrome and its components in the general adult population: a meta-analysis of global data from 28 million individuals. *Diabetes Research and Clinical Practice*, 109924. doi: 10.1016/j.diabres.2022.109924.

[47] Da Poian A. T., El-Bacha T. and Luz M. R. M. P. (2010). Nutrient Utilization in Humans: Metabolism Pathways. *Nature Education* 3 (9): 11.

[48] Kaushik S. (2020). *Carbohydrate, protein and lipid metabolism*. In Mukhopadhaya N., Pundir J. and Arora M. (Eds.), Part 1 MRCOG Revision Notes and Sample SBAs (pp. 227-245). Cambridge: Cambridge University Press. doi: 10.1017/9781108644396.037.

[49] Chakravarthy M. V. and Neuschwander-Tetri B. A. (2020). The metabolic basis of nonalcoholic steatohepatitis. *Endocrinology, Diabetes and Metabolism*, 3 (4): e00112. doi: 10.1002/edm2.112.

[50] Kojta I., Chacińska M. and Błachnio-Zabielska A. (2020). Obesity, bioactive lipids and adipose tissue inflammation in insulin resistance. Nutrients, 12 (5). doi: 10.3390/nu12051305.

[51] Liu Z., Wu K. K., Jiang X., Xu A. and Cheng K. K. (2020). The role of adipose tissue senescence in obesity-and ageing-related metabolic disorders. *Clinical Science* 134 (2): 315-330. doi: 10.1042/CS20190966.

[52] Saltiel, A. R. and Olefsky, J. M. (2017). Inflammatory mechanisms linking obesity and metabolic disease. *The Journal of Clinical Investigation*, 127 (1): 1-4. doi: 10.1172/JCI92035.

[53] Scheja, L., Heeren, J. (2019). The endocrine function of adipose tissues in health and cardiometabolic disease. *Nature Reviews Endocrinology*, *Nat Rev Endocrinol*, 15: 507–524. doi: 10.1038/s41574-019-0230-6.

[54] Wang H. H., Lee D. K., Liu M., Portincasa P. and Wang, D. Q. (2020). Novel insights into the pathogenesis and management of the metabolic syndrome. *Pediatric Gastroenterology, Hepatology & Nutrition*, *23* (3): 189-230. doi: 10.5223/pghn.2020.23.3.189.

[55] Grandl G. and Wolfrum C. (2018). Hemostasis, endothelial stress, inflammation and the metabolic syndrome. *Seminar in Immunopathol*, 40: 215-224. doi: 10.1007/s00281-017-0666-5.

[56] Varghese J. F., Patel R. and Yadav, U. (2018). Novel insights in the metabolic syndrome-induced oxidative stress and inflammation-mediated atherosclerosis. *Current Cardiology Reviews*, 14 (1): 4-14. doi: 10.2174/1573403X13666171009112250.

[57] Moldogazieva N. T., Mokhosoev, I. M., Mel'nikova T. I., Porozov Y. B. and Terentiev A. A. (2019). Oxidative stress and advanced lipoxidation and glycation end products (ALEs and AGEs) in aging and age-related diseases. *Oxidative medicine and cellular longevity* 2019: 3085756. doi: 10.1155/2019/3085756.

[58] Pitsavos C., Panagiotakos D., Weinem M., Stefanadis C. (2006). Diet, exercise and the metabolic syndrome. *The Review of Diabetic Studies 2006 Fall*, 3 (3): 118-26. doi: 10.1900/RDS.2006.3.118.

[59] Hoyas I. and Leon-Sanz M. (2019). Nutritional Challenges in Metabolic Syndrome. Journal of Clinical Medicine, 8: 1301. doi: 10.3390/jcm8091301.

[60] Jabczyk M., Nowak J., Hudzik B. and Zubelewicz-Szkodzińska B. (2021). Curcumin in Metabolic Health and Disease. *Nutrients*, *13* (12): 4440. doi: 10.3390/nu13124440.

[61] Halle M. P., Kom M. F., Kamdem F., Mouliom S., Fouda H., Dzudie A., Kaze F. F. and Ashuntantang E. G. (2020). Cardiovascular disease burden in patients with non-dialysis dependent chronic kidney disease in Cameroon: Case of the Douala General Hospital. *Open Journal of Nephrology* 10 (03): 101329. doi: 10.4236/ojneph.2020.103017.

[62] Mbouemboue, O. P., Touko, A. M., Haman, H. S., Amanissa, P. D., Damdam, F. B., Ngoufack, J. O. and Tamanji, M. T. (2017). One-year follow-up of the distribution of dyslipidemias among Cameroonian diabetic patients in Ngaoundere, 2014-2015. *Cardiology and Angiology: An International Journal* 6 (4): 1-9. doi: 10.9734/CA/2017/37773.

[63] Noumi E., Houngue F., Lontsi D. (1999). Traditional medicines in primary health care: plants used for the treatment of hypertension in Bafia, Cameroon. *Fitoterapia* 70: 134-139.

[64] Din N., Dibong S. D., Mpondo M. E., Priso R. J., Kwin M. F. and Ngoye A. (2011). Inventory and identification of plants used in the treatment of diabetes in Douala town (Cameroon). *European Journal of Medicinal Plants* 1 (3): 60-73.

[65] Koyeu T. E., Mendi G., Tchamago F. X., Tajeukem V. C., Franklin V. and Linda C. (2014). Ethnobotanic contribution of Cameroon: Anti- diabetic plants inventory in the Nkoung–Khi division West region Cameroon. *Applied Science Reports* 8 (3): 125-133.

[66] Tsabang N., Yedjou C. G., Tsambang L., Tchinda A. T., Donfagsiteli N., Agbor G. A., Tchounwou P. and Nkongmeneck B. A. (2015). Treatment of diabetes and/or hypertension using medicinal plants in Cameroon. *Medicinal & aromatic plants*, 2015 (Suppl 2): 003. doi: 10.4172/2167-0412.S2-003.

[67] Tsabang N., Tsambang D. W. L., Tsambang F. S. C. and Agbor A. G. 2016a. Ethnomedical and ethnopharmacological study of plants used for potential treatments of diabetes and arterial hypertension by indigenous people in three phytogeographic regions of Cameroon. *Diabetes Case Report*, 1 (2): 110. doi: 10.4172/2572-5629.1000110.

[68] Tsabang N., Ngah N., Estella F. T., Agbor G. A. 2016b. Herbal medicine and treatment of diabetes in Africa: Case study in Cameroon. *Diabetes Case Rep* 1 (2): 112.

[69] Tsabang N., Tsambang D. L. W., Yedjou C. G. and Tchounwou P. B. (2019). Importance of food plants in the prevention and treatment of diabetes in Cameroon. *Bioactive Compounds in Health and Disease*, 2 (2): 11-26. doi: 10.31989/bchd.v2i2.554.

[70] Epoh N. J., Matafack D. O. L., Tchouanguep M. F. and Telefo P. B. (2020). Ethnobotanical study of medicinal plants used as anti-obesity remedies in Foumban and Dschang cities (West-Cameroon). *European Journal of Medicinal Plants*, 31 (9): 54-70. doi: 10.9734/ejmp/2020/v31i930271.

[71] Tankeu S. E., Etame-Loe G. M., Fannang S. V., Ladoh Y. C. F., Ngouondjou F. T., Bamal H. and Ndongo D. (2021). Ethnobotanical studies of plants with antihypertensive properties in the city of Nkongsamba, Cameroon. *Saudi Journal of Medical and Pharmaceutical Sciences*, *7* (6): 251-261. doi: 10.36348/sjmps.2021.v07i06.005.

[72] Jiofack T., Fokunang C., Kemeuze V., Fongnzossie E., Tsabang N., Nkuinkeu R., Mapongmetsem P. M. and Nkongmeneck B. A. (2008). Ethnobotany and phytopharmacopoea of the South-West ethnoecological region of Cameroon. *Journal of Medicinal Plants Research*, 2 (8): 197-206.

[73] Focho D. A., Ndam W. T. and Fonge B. A. (2009). Medicinal plants of Aguambu – Bamumbu in the Lebialem highlands, southwest province of Cameroon. *African Journal of Pharmacy and Pharmacology*, 3 (1): 001-013.

[74] Jiofack T., Ayissi I., Fokunang C., Guedje N. and Kemeuze V. 2009a. Ethnobotany and phytomedicine of the upper Nyong valley forest in Cameroon. *African Journal of Pharmacy and Pharmacology*, 3 (4): 144-150.

[75] Jiofack T., Fokunang C., Guedje N., Kemeuze V., Fongnzossie E., Nkongmeneck B. A., Mapongmetsem P. M. and Tsabang N. 2009b. Ethnobotanical uses of some plants of two ethnoecological regions of Cameroon. *African Journal of Pharmacy and Pharmacology*, 3 (13): 664-684.

[76] Ndenecho E. N. (2009). Herbalism and resources for the development of ethnopharmacology in Mount Cameroon region. *African Journal of Pharmacy and Pharmacology*, 3 (3): 078-086.

[77] Dibong S. D., Mpondo M. E., Ngoye A. and Kwin M. F. (2011). Plantes médicinales utilisées par les populations Bassa de la région de Douala au Cameroun. *International Journal of Biological and Chemical Sciences*, 5 (3): 1105-1117.

[78] Mpondo M. E. and Dibong S. D. (2012). Traditional knowledge on medicinal plants use by ethnic communities in Douala, Cameroon. *European Journal of Medicinal Plants*, 2 (2): 159-176.

[79] Ndah N. R., Enow E. A., Bechem E., Asaha S., Yengo T., Loh C. E. and Eyenieh N. M. (2013). Ethnobotanical study of commonly used medicinal plants of the Takamanda Rainforest South West, Cameroon. *African Journal of Plant Science*, 7 (1): 21-34. doi: 10.5897/AJPS12.111.

[80] Bayaga, H. N., Guedje NM, Ondoua, N. M. O., Njinkio, N. B. L., Ngameni, B,. Fokunang, C. and Ngadjui, T. B. (2021). Ethno Pharmacological Survey of the Medicinal Flora Used by Some Traditional Healers of Mbam and Inoubou Division (Cameroon). *Saudi Journal of Medical and Pharmaceutical Sciences*, *7* (9): 445-454. doi: 10.36348/sjmps.2021.v07i09.003.

[81] Nnanga, J. F., Sassou, C. B., Wouokoue, J. T., Todou, G., Tchobsala, D. and Moksia, F. (2022). Quantitative, phytomedicinal and ethnobotanical study of plants in the Far-north region of Cameroon: Case of Yagoua Sub-Division. *Research Square*, (2022). doi: 10.21203/rs.3.rs-2056855/v1.

[82] Dzeufiet D. P. D., Tadondjou T. C. D., Bilanda D. C., Aboubakar O. B. F., Kamtchouing P. and Dimo T. 2013). Endothelium-dependent and independent vasorelaxant effect of *Terminalia superba* (Combretaceae) on rat aorta. *The Journal of Phytopharmacology*, 2 (5): 21-27.

[83] Tom E. N. L., Demougeot, C., Mtopi, O. B., Dimo, T., Djomeni, P. D. D., Bilanda, D. C., Girard C. and Berthelot, A. (2011). The Extract of *Terminalia superba* (Combretaceae) prevents glucose-induced hypertension in rats. *Journal of Ethnopharmacology*, *133* (2): 828-833. doi: 10.1016/j.jep.2010.11.016.

[84] Tom E. N. L., Girard-Thernier, C., Martin, H., Dimo, T., Alvergnas, M., Nappey, M., Berthelot A. and Demougeot, C. (2014). Treatment with an extract of *Terminalia superba* Engler and Diels decreases blood pressure and improves endothelial function in spontaneously hypertensive rats. *Journal of ethnopharmacology* 151 (1): 372-379.

[85] Momo, C. E. N., Ngwa, A. F., Dongmo, G. I. F. and Oben, J. E. (2009). Antioxidant properties and α-amylase inhibition of *Terminalia superba*, *Albizia sp.*, *Cola nitida*, *Cola odorata* and *Harungana madagascarensis* used in the management of diabetes in Cameroon. *Journal of Health Science*, 55 (5): 732-738. doi: 10.1248/jhs.55.732.

[86] Kamtchouing, P., Kahpui, S. M., Dzeufiet, D. P. D., Tédong, L., Asongalem, E. A. and Dimo, T. (2006). Anti-diabetic activity of methanol/methylene chloride stem bark extracts of Terminalia superba and Canarium schweinfurthii on streptozotocin-induced diabetic rats. *Journal of Ethnopharmacology*, 104 (3): 306-309. doi: 10.1016/j.jep.2005.08.075.

[87] Dzeufiet, P. D. D., Mogueo, A., Bilanda, D. C., Aboubakar, B. F. O., Tédong, L., Dimo, T. and Kamtchouing, P. (2014). Antihypertensive potential of the extract which combine leaf of *Persea americana* Mill. (Lauraceae), stems and leaf of *Cymbopogon citratus* (DC) Stapf. (Poaceae), fruits of *Citrus medical* L. (Rutaceae) as well as honey in ethanol and sucrose experimental model. *BMC complementary and alternative medicine*, 14: 507. doi: 10.1186/1472-6882-14-507.

[88] Bilanda, D. C., Dzeufiet, P. D. D., Fouda, Y. B., Ngapout, R. F., Tcheutchoua, Y., Owona, P. E., Wouamba NS. C Tatchou T. L, Dimo T. and Kamtchouing, P. (2020). Antihypertensive and antidiabetic activities of *Erythrina senegalensis* DC (Fabaceae) stem bark extract on diabetic hypertensive rats. *Journal of ethnopharmacology*, 246: 112200. doi: 10.1016/j.jep.2019.112200.

[89] Nguelefack-Mbuyo E. P., Dongmo A. B., Nguelefack T. B., Kamanyi A., Kamtchouing P., Dimo T. (2012). "Endothelium/nitric oxide mediates the vasorelaxant and antihypertensive effects of the Extract from the stem bark of *Mammea africana* Sabine (Guttiferae)", *Evidence-Based Complementary and Alternative Medicine*, 2012: 961741. doi: 10.1155/2012/961741.

[90] Nguelefack-Mbuyo P. E., Nguelefack T. B., Dongmo A. B., Afkir S., Azebaze A. G. B., Dimo T. and Ziyyat A. (2008). Anti-hypertensive effects of the methanol/methylene chloride stem bark extract of *Mammea africana* in L-NAME-induced hypertensive rats. *Journal of Ethnopharmacology*, 117 (3): 446-450. doi: 10.1016/j.jep.2008.02.028.

[91] Tchamadeu, M. C., Dzeufiet, P. D. D., Nouga, C. K., Azebaze, A. G. B., Allard, J., Girolami, J. P., Tack I., Kamtchouing P. and Dimo, T. (2010). Hypoglycaemic effects of *Mammea africana* (Guttiferae) in diabetic rats. *Journal of Ethnopharmacology*, *127* (2): 368-372. doi: 10.1016/j.jep.2009.10.029.

[92] Azantsa, B. K. G, Ntentie, F. R., Mbong, A. M. A., Mafongang, A, Kamtchoum, A., Momo, C., Chimou, N. L., Fonkoua, M., Edoun, E. F., Ngondi, J. L. and Oben, J. E. (2022). Lipomodulatory and anti-oxidative stress effects of a polyherbal formulation based on garlic and avocado seeds extracts on high fat high sucrose diet fed rats. *Metabolism open*, 15: 100195. doi: 10.1016/j.metop.2022.100195.

[93] Yetendje, L. C., Njateng, G. S. S., Dongmo, A. J. A., Mouokeu, R. S., Feudjio, C., Tamekou, S. L. and Iqbal, J. (2019). *In vivo* antidiabetic activity and mechanism of action of three Cameroonian medicinal plant extracts. *International Journal of Research–Granthaalayah 7* (8): 415-430.

[94] Njateng G. S., Zaib S., Chimi L. Y., Feudjio C., Mouokeu R. S., Gatsing D., Kuiate J. R., Adewole E., Iqbal J. (2018). Antidiabetic potential of methanol extracts from leaves of *Piper umbellatum* L. and *Persea americana* Mill. *Asian Pacific Journal of Tropical Biomedicine*, *8* (3): 160-165. https: //www.apjtb.org/text.asp?2018/8/3/160/227997

[95] Kuate, D., Etoundi, O. B. C., Ngondi, J. L. and Oben, J. E. (2011). Effects of Dichrostachys glomerata spice on cardiovascular diseases risk factors in normoglycemic and type 2 diabetic obese volunteers. *Food research international*, *44* (5): 1197-1202. doi: 10.1016/j.foodres.2010.09.037.

[96] Kuate, D., Etoundi, O. B. C., Ngondi, J. L., Muda, W. and Oben, J. E. (2013). Anti-inflammatory, anthropometric and lipomodulatory effects Dyglomera® (Extract of Dichrostachys glomerata) in obese patients with metabolic syndrome. *Functional Foods in Health and Disease*, *3* (11): 416-427. doi: 10.31989/ffhd.v3i11.35.

[97] Ngatchic M. T. J., Douanla N. F. N., Ndjantou E. B., Njintang Y. N. (2020). Lipid-lowering and anti-lipase properties of powder fractions of *Dichrostachys glomerata* fruits. *Asian Journal of Medical Sciences*, 11 (5): 69-76.

[98] Etoundi, C. B., Kuaté, D., Ngondi, J. L. and Oben, J. (2010). Anti-amylase, anti-lipase and antioxidant effects of extracts of some Cameroonian spices. *Journal of Natural Products*, *3* (165): 17.

[99] Nwakiban A. P. A, Sokeng A. J., Dell'Agli M., Bossi L., Beretta G., Gelmini F., Deutou T. A., Agbor A. G., Kuiaté J. R. and Magni P. (2019). Hydroethanolic plant extracts from Cameroon positively modulate enzymes relevant to carbohydrate/lipid digestion and cardio-metabolic diseases. *Food and function*, 10 (10): 6533-6542. doi: 10.1039/C9FO01664C.

[100] Nwakiban A. A. P., Passarelli A., Da Dalt L., Olivieri C., Demirci T. N., Piazza S., Sangiovanni E., Carpentier-Maguire E., Martinelli G., Shivashankara S. T., Manjappara U. V., Tchamgoue A. D., Agbor G. A., Kuiate J. R., Daglia M., Dell'A. M., Magni P. (2021). Cameroonian spice extracts modulate molecular mechanisms relevant to cardiometabolic diseases in SW 872 human Liposarcoma cells. *Nutrients,* 13: 4271. doi: 10.3390/nu13124271.

[101] Dongmo, O. L. M., Ashu, E. L. A., Tadjoua, H. T., Epoh, N. J., Njina, S. N., Tapondjou, L. A. and Telefo, P. B. (2019). Evaluation of anti-obesity and diuretic effects of Extract of *Tetrapleura tetraptera* Taub. stem bark on high fat diet-induced obese rats. *European Journal of Pharmaceutical and Medical Research*, 6 (1): 27-37.

[102] Kuate, D., Kengne, A. P. N., Biapa, C. P. N., Azantsa, B. G. K. and Wan M. W. A. M. B. (2015). *Tetrapleura tetraptera* spice attenuates high-carbohydrate, high-fat diet-induced obese and type 2 diabetic rats with metabolic syndrome features. *Lipids in Health and Disease*, 14 (1): 1-13. doi: 10.1186/s12944-015-0051-0.

[103] Eyenga, M., Takuissu, N. G. R., Ziyyat, A., Ngondi, J. L. and Sindic, M. (2020). Hypoglycaemic activity of preheated (roasting) *Aframomum citratum* (C. Pereira) K. Schum and *Tetrapleura tetraptera* (Schumach and Thonn.) fruits beverage on Streptozotocin-induced rats. *Journal of Pharmacognosy and Phytotherapy*, 12 (2): 44-61. doi: 10.5897/JPP2019.0570.

[104] Tcheutchoua, Y. C., Bilanda, D. C., Dzeufiet, P. D. D., Djunie Neali, O. C., Owona, P. E., Ngapout, R. F., Noubom M., Dimo T. and Kamtchouing, P. (2022). Preventive potential of the Extract of the mixture of Bidens pilosa (Asteraceae) and Cymbopogon citratus (Poaceae) aerial parts on hypertension induced by a chronic salt and alcohol consumption on the rats. *Evidence-Based Complementary and Alternative Medicine*, 2022: 1980622. doi: 10.1155/2022/1980622.

[105] Massa Z. B., Ngueguim T. F., Gounoue K. R., Fouda B Y, Wendja N M A and Dimo T. (2021). Antidiabetic effects of Extract of *Baillonella toxisperma* Pierre (Sapotacae) in streptozotocin-induced diabetic rats. *Journal of Medicinal Plants Studies*, 9 (4): 28-37 doi: 10.22271/plants.2021.v9.i4a.1308.

[106] Nguélé, L. R., Fokunang, C. and Etoundi, C. B. (2012). Control of some composants of metabolic syndrome by hydroetanolic extracts of *Aframomum aulacocorpus*, *A. citratum* and *A. daniellii* (Hook. F) K. Schum. *Health Sciences and Disease*, 13 (3).

[107] Sokeng, S. D., Lontsi, D., Moundipa, P. F., Jatsa, H. B., Watcho, P. and Kamtchouing, P. (2007). Hypoglycemic effect of *Anacardium occidentale* L. methanol extract and fractions on streptozotocin-induced diabetic rats. *Global Journal of Pharmacology*, 1 (1): 1-5.

[108] Tedong, L., Madiraju, P., Martineau, L. C., Vallerand, D., Arnason, J. T., Desire, D. D., Lavoie L., Kamtchouing P and Haddad, P. S. (2010). Hydro-ethanolic extract of cashew tree (Anacardium occidentale) nut and its principal compound, anacardic acid, stimulate glucose uptake in C2C12 muscle cells. *Molecular nutrition and food research*, 54 (12): 1753-1762. doi: 10.1002/mnfr.201000045.

[109] Tedong, L., Dzeufiet, P. D. D., Asongalem, A. E., Sokeng, D. S., Callard, P. and Kamtchouing, P. (2006). Antihyperglycemic and renal protective activities of *Anacardium occidentale* (Anacardiaceae) leaves in streptozotocin induced diabetic rats. *African Journal of Traditional, Complementary and Alternative Medicines*, *3* (1): 23-35.

[110] Kamtchouing, P., Sokeng, S. D., Moundipa, P F., Watcho, P., Jatsa, H. B. and Lontsi, D. (1998). Protective role of *Anacardium occidentale* extract against streptozotocin-induced diabetes in rats. *Journal of ethnopharmacology,* 62 (2): 95-99. doi: 10.1016/S0378-8741(97)00159-1.

[111] Dimo, T., Rakotonirina, S. V., Tan, P. V., Azay, J., Dongo, E., Kamtchouing, P. and Cros, G. (2007). Effect of *Sclerocarya birrea* (Anacardiaceae) stem bark methylene chloride/methanol extract on streptozotocin-diabetic rats. *Journal of Ethnopharmacology*, 110 (3): 434-438. doi: 10.1016/j.jep.2006.10.020.

[112] Nyunaï, N., Njikam, N., Abdenneb, E., Mbafor, J. and Lamnaouer, D. (2009). Hypoglycaemic and antihyperglycaemic activity of Ageratum conyzoides L. in rats. *African Journal of Traditional, Complementary and Alternative Medicines*, 6 (2). doi: 10.4314/ajtcam.v6i2.57083.

[113] Nyunaï, N., Manguelle-Dicoum, A., Njifutié, N., Abdennebi, E. H. and Gerard, C. (2010). Antihyperglycaemic effect of Ageratum conyzoides L. fractions in normoglycemic and diabetic male wistar rats. *International Journal of Biomedical and Pharmaceutical Sciences*, *4* (1): 38-42.

[114] Nyunaï N., Abdennebi E. H., Bickii J. and Manguelle-Dicoum M. A. (2015). Subacute antidiabetic properties of *Ageratum conyzoides* leaves in diabetic rats. *International Journal of Pharmaceutical Sciences and Research*, 6 (4): 1378-1387. doi: 10.13040/IJPSR.0975-8232.6(4).1378-87.

[115] Kamani, S. P., Waguia, J. K., Miaffo, D., Nchouwet, M., Kadji, C. D., Kamgaing, M. W., Douho D. J., Mzoyem N. A. K., Wansi N. S. and Ngnokam, S. W. (2022). Efficacy of *Emilia coccinea* extract on inhibition of α-amylase enzyme activity and insulin resistance in dexamethasone treated-rats. *Metabolism Open*, 100193. doi: 10.1016/j.metop.2022.100193.

[116] Moukette, B. M., Ama, M. V. J., Biapa, N. C. P., Nanfack, P., Nzufo, F. T., Kenfack, M. A., Ngongang Y. J. and Pieme, C. A. (2017). Antioxidant and synergistic antidiabetic activities of a three-plant preparation used in Cameroon folk medicine. *International scholarly research notices*, 2017: 9501675. doi: 10.1155/2017/9501675.

[117] Fofie, C. K., Wansi, S. L., Nguelefack-Mbuyo, E. P., Atsamo, A. D., Watcho, P., Kamanyi, A., Nole, T. and Nguelefack, T. B. (2014). *In vitro* anti-hyperglycemic and antioxidant properties of extracts from the stem bark of *Ceiba pentandra*. *Journal of Complementary and Integrative Medicine*, 11 (3): 185-193. doi: 10.1515/jcim-2014-0031.

[118] Nguelefack T. B., Fofie K. C., Nguelefack-Mbuyo E. P., Kaptue W. A. (2020). Multimodal *α*-Glucosidase and *α*-Amylase Inhibition and Antioxidant Effect of the Aqueous and Methanol Extracts from the Trunk Bark of *Ceiba pentandra*. *BioMed Research International*, 2020: 3063674. doi: 10.1155/2020/3063674.

[119] Djomeni, P. D. D., Tédong, L., Asongalem, E. A., Dimo, T., Sokeng, S. D. and Kamtchouing, P. (2006). Hypoglycaemic and antidiabetic effect of root extracts of Ceiba pentandra in normal and diabetic rats. *African Journal of Traditional, Complementary and Alternative Medicines*, 3 (1). doi: 10.4314/ajtcam.v3i1.31147.

[120] Dzeufiet, P. D. D., Ohandja, D. Y., Tédong, L., Asongalem, E. A., Dimo, T., Sokeng, S. D. and Kamtchouing, P. (2007). Antidiabetic effect of *Ceiba pentandra* extract on streptozotocin-induced non-insulin-dependent diabetic (NIDDM) rats. *African Journal of Traditional, Complementary and Alternative Medicines*, *4* (1): 47-54. doi: 10.4314/ajtcam.v4i1.31191.

[121] Kouambou, C., Dimo, T., Dzeufiet, P., Ngueguim, F., Tchamadeu, M., Wembe, E. and Kamtchouing, P. (2007). Antidiabetic and hypolipidemic effects *of Canarium schweinfurthii* hexane bark extract in streptozotocin-diabetic rats. *PharmacologyOnline* 1: 209-219.

[122] Njapndounke, B., Kouam, M. E. F., Boungo, G. T., Klang, J. M. and Ngoufack, F. Z. (2021). Optimization of production conditions of biscuit from *Musa sapientum* flour (‘banane cochon’): Nutritional composition and glycaemic index of the optimized biscuit. *Journal of Agriculture and Food Research*, *6*: 100229. doi: 10.1016/j.jafr.2021.100229.

[123] Ngondi J. L., Makamto S. C. and Oben J. E. (2005). *Irvingia Gabonensis* on Body weight and bloods lipids in normolipidemic guinea pigs. *Journal of Food Technology*, 3: 472-474.

[124] Ngondi, J. L., Oben, J. E. and Minka, S. R. (2005). The effect of Irvingia gabonensis seeds on body weight and blood lipids of obese subjects in Cameroon. *Lipids in health and Disease*, 4 (1): 1-4. doi: 10.1186/1476-511X-4-12.

[125] Ngondi, J. L., Fossouo, Z., Djiotsa, E. J. and Oben, J. E. (2006). Glycaemic variations after administration of *Irvingia gabonensis* seeds fractions in normoglycemic rats. *African Journal of Traditional, Complementary and Alternative Medicines*, *3* (4): 94-101. doi: 10.4314/ajtcam.v3i4.31181.

[126] Oben, J. E., Ngondi, J. L. and Blum, K. (2008). Inhibition of *Irvingia gabonensis* seeds extract (OB131) on adipogenesis as mediated via down regulation of the PPARgamma and leptin genes and up-regulation of the adiponectin gene. *Lipids in Health and Disease*, *7* (1): 1-6. doi: 10.1186/1476-511X-7-44.

[127] Oben, J. E., Ngondi, J. L., Momo, C. N., Agbor, G. A. and Sobgui, C. S. M. (2008). The use of a Cissus quadrangularis/Irvingia gabonensis combination in the management of weight loss: a double-blind placebo-controlled study. *Lipids in Health and Disease*, 7 (1): 1-7. doi: 10.1186/1476-511X-7-12.

[128] Hossain, M. S., Sokeng, S., Shoeb, M., Hasan, K., Mosihuzzaman, M., Nahar, N., Ali, L. and Rokeya, B. (2012). Hypoglycemic effect of Irvingia gabonensis (Aubry-Lacomate Ex. Ororke), Baill in type 2 diabetic long-evans rats. *Dhaka University Journal of Pharmaceutical Sciences*, 11 (1): 19-24. http: //dx.doi.org/10.3329/dujps.v11i1.12482

[129] Woguia, A. L., Ngondi, J. L. and Oben, J. E. (2011). Effect of two Cameroonian plants mucilage on food intake, body weight gain, lipidemic and oxidative status in rats fed high-fat diet. *Canadian Journal of Diabetes*, 35 (2): 175-176. doi: 10.1016/S1499-2671(11)52138-0.

[130] Matsinkou, R. S., Ngondi, J. L., Kuate, D., Mbofung, C. and Oben, J. E. (2012). Antioxidant and anti-hyperglycemic potential of pulp extracts of *Irvingia wombolu* fruits. *Biology and Medicine* 4 (1): 10-19.

[131] Deutchoua N. E. M., Mang Y. D., Dongmo F., Youdom P., Sokeng D. S., Njintang Y. N. (2021). Effect of Extract of Linn. leaves on the onset of *Clerodendrum thomsoniae* hyperlipidaemia and the inhibition of gain mass on wistar rats. *Asian Journal of Pharmacy and Pharmacology*, 7 (6): 247-255. doi: 10.31024/ajpp.2021.7.6.2.

[132] Nkepndep T. S. V., Dongho D. F. F., Lienou L. L., Maffo T. G., Djeukeu A. W., Manz K. J. C., Bogning Z. C., Mbiatat H. D. G., Ebelle E. R. M., Gouado I. (2022). *In vitro* and *In vivo* antioxidant and antiobesogenic properties of Extracts of *Hibiscus sabdariffa, Zingiber officinale and Mentha spicata* in Wistar high-fat diet rats. *J Food Nutr Sc.* 10 (5): 151–164. doi: 10.11648/j.jfns.20221005.11.

[133] Feudjio, C., Sedar, G., Njateng, S. and Kuiate, J. (2018). Evaluation of antidiabetic activity of extract of leaves from *Phragmanthera capitata* (Sprengel) S. Balle (Laurenthaceae) in Wistar albino Rats. *Journal of Diseases and Medicinal Plants*, 4 (4): 96-109. doi: 10.11648/j.jdmp.20180404.11.

[134] Tchamadeu, M. C., Dzeufiet, P. D. D., Blaes, N., Girolami, J. P., Kamtchouing, P. and Dimo, T. (2017). Antidiabetic effects of aqueous and dichloromethane/methanol stem bark extracts of *Pterocarpus soyauxii* Taub (Papilionaceae) on streptozotocin-induced diabetic rats. *Pharmacognosy research*, 9 (1): 80.

[135] Takem L. P., Lawal B. A. S., Udia P. M., Udoh F. V. (2015). Assessment of glycaemic property of *Phragmanthera capitata*. *Ijppr*. *Human* 4 (4): 1-8.

[136] Takem, L. P., Essien, A. D., Udia, P. M. and Anele, E. I. 2015b. Evaluation of lipogenic property of Phragmanthera capitata in diabetic rats. *The Journal of Phytopharmacology*, 4 (6): 299-302.

[137] Nguekouo, P. T., Kuate, D., Kengne, A. P. N., Woumbo, C. Y., Tekou, F. A. and Oben, J. E. (2018). Effect of boiling and roasting on the antidiabetic activity of *Abelmoschus esculentus* (Okra) fruits and seeds in type 2 diabetic rats. *Journal of Food Biochemistry*, 42 (6): e12669. doi: 10.1111/jfbc.12669.

[138] Njike, G. N., Watcho, P. and Kamanyi, A. (2005). Hypoglycaemic activity of the leaves extracts of *Bersama engleriana* in rats. *African Journal of Traditional, Complementary and Alternative Medicines*, 2 (3): 215-221.

[139] Watcho P., Achountsa J. H. G., Mbiakop C. U., Wankeu N. M., Nguelefack T. B. and Kamanyi A. (2012). Hypoglycemic and hypolipidemic effects of *Bersama engleriana* leaves in nicotinamide/streptozotocin-induced type 2 diabetic rats. *BMC Complementary Medicine and Therapies,* 12: 264. doi: 10.1186/1472-6882-12-264.

[140] Ngueguim T. F., Dimo T., Dzeufiet D. P. D., Vouffo B., Dongo E., Renaud B., Asongalem A. E., Zapfack L. and Kamtchouing P. (2007). Antidiabetic activities of methanol-derived extract of *Dorstenia picta* twigs in normal and streptozotocin-induced diabetic rats. *Asian Journal of Traditional Medicines*, 2 (4): 140-148.

[141] Kolefer, K., Miaffo, D. and Ponka, R. (2021). Evaluation of antidiabetic properties of the leaves extract of Ficus vallis-choudae Delile in a model of type 2 diabetes induced by high-fat diet and streptozotocin. *The Scientific World Journal*, 2021: 1502230. doi: 10.1155/2021/1502230.

[142] Njapndounke, B., Saah, M. B. D., Kouam, M. E. F., Boungo, G. T. and Ngoufack, F. Z. (2021). Optimum biscuit from *Musa sapientum* L. and *Vigna unguiculata* L. composite flour: effect on pancreatic histology, biochemical and hematological parameters of diabetic rats. *Heliyon*, *7* (9): e07987. doi: 10.1016/j.heliyon.2021.e07987.

[143] Mballa, L. E. D., Yadang, F. S., Tchamgoue, A. D., Mba, J. R., Tchokouaha, L. R., M Biang, E., Tchinda T. A., Djomeni D. D. P. and Agbor, G. A. (2021). Cafeteria diet-induced metabolic and cardiovascular changes in rats: The role of *Piper nigrum* leaf extract. *Evidence-Based Complementary and Alternative Medicine*, 2021: 5585650. doi: 10.1155/2021/5585650.

[144] Domekouo, U. L., Longo, F., Tarkang, P. A., Tchinda, A. T., Tsabang, N., Donfagsiteli, N. T., Tamze V., Kamtchouing, P. and Agbor, G. A. (2016). Evaluation of the antidiabetic and antioxidant properties of *Morinda lucida* stem bark extract in streptozotocin intoxicated rats. *Pakistan journal of pharmaceutical sciences*, *29* (3): 903-911.

[145] Fouda, Y. B., Tom, E. N. L., Atsamo, A. D., Bonabe, C. and Dimo, T. (2020). Effects of stem bark Extract of Fagara tessmannii Engl (Rutaceae) on cardiovascular risks related to monosodium glutamate-induced obesity in rat: *In vivo* and *In vitro* assessments. *Journal of ethnopharmacology*, 260: 112972. doi: 10.1016/j.jep.2020.112972.

[146] Miaffo, D., Guessom Kamgue, O., Ledang Tebou, N., Maa T. C. and Kamanyi, A. (2019). Antidiabetic and antioxidant potentials of Vitellaria paradoxa barks in alloxan-induced diabetic rats. *Clinical Phytoscience,* 5 (1): 1-8. doi: 10.1186/s40816-019-0141-z.

[147] Miaffo, D., Ntchapda, F., Mahamad, T. A., Maidadi, B. and Kamanyi, A. (2021). Hypoglycemic, antidyslipidemic and antioxydant effects of *Vitellaria paradoxa* barks extract on high-fat diet and streptozotocin-induced type 2 diabetes rats. *Metabolism Open*, 9: 100071. doi: 10.1016/j.metop.2020.100071.

[148] Kasali, F. M., Fokunang, C. N., Ngoupayo, J., Tembe-Fokunang, E., Ngameni, B., Njinkio, B., Frederick K., Justin N., Tsague M, Oyono V., Mbacham W. and Ngadjui, B. T. (2016). Evaluation of the antidiabetic properties of hydro-alcoholic extract and its fractions from Physalis peruviana L. leaves on streptozotocin-induced diabetic Wistar rats. *Journal of Diseases and Medicinal Plants*, *2* (6): 67-73.

[149] Fokunang, C. N., Mushagalusa, F. K., Tembe-Fokunang, E., Ngoupayo, J., Ngameni, B., Njinkio, L. N., Kadima J. N., Kechia F., Atogho-Tiedeu A. B., Mbacham W. F. and Ngadjui, B. T. (2017). Phytochemical and zootechnical studies of *Physalis peruviana* L. leaves exposured to streptozotocin-induced diabetic rats. *Journal of Pharmacognosy and Phytotherapy*, 9 (8): 123-130. doi: 10.5897/JPP2016.0418.

[150] Dakam, W., Biyegue, C. F. N., Fannang, S. V. and Oben, J. E. (2021). Leaf extracts of *Glyphaea brevis* attenuate high blood glucose and lipids in diabetic rats induced with streptozotocin. *Pharmacognosy Research*, *13* (2). doi: 10.4103/pr.pr_99_20.

[151] Momo C. E. N., Oben J. E., Tazoo D. and Dongo E. (2006). Antidiabetic and hypolipidaemic effects of a methanol/methylene-chloride extract of *Laportea ovalifolia* (Urticaceae), measured in rats with alloxan-induced diabetes. *Annals of Tropical Medicine and Parasitology*, 100 (1): 69-74, doi: 10.1179/136485906X78517.

[152] Deutchoua E. M., Mang Y. D., Sokeng D. S. and Njintang Y. N. (2020). Hypolipidemic and antioxidant activity of Extract of *Clerodendrum thomsoniae* Linn. (Verbenaceae) leaves in albino rats, Rattus norvegicus (Muridae). *Journal of Pharmacognosy and Phytochemistry*, 9 (1): 595-602.

[153] Talba, M. A., Miaffo, D., Poualeu K. S. L., Kamanyi, A. and Wansi, S. L. (2019). Antioxidant properties and digestive enzyme inhibitory activity of the Extract from leafy stems of Cissus polyantha. *Evidence-Based Complementary and Alternative Medicine*, 2019: 7384532. doi: 10.1155/2019/7384532.

[154] Mahamad, A. T., Miaffo, D., Poualeu Kamani, S. L., Mahamat, O., Kamanyi, A. and Wansi Ngnokam, S. L. (2020). Glucose, lipid and oxidative stress lowering activity of the Extract from leafy stems of *Cissus polyantha* Gilg and Brandt in dexamethasone-induced hyperglycemia in rats. *Journal of Diabetes and Metabolic Disorders*, *19* (2): 1527-1535. doi: 10.1007/s40200-020-00687-x.

[155] Oben, J., Kuate, D., Agbor, G., Momo, C. and Talla, X. (2006). The use of a *Cissus quadrangularis* formulation in the management of weight loss and metabolic syndrome. *Lipids in Health and Disease*, *5* (1): 1-7. doi: 10.1186/1476-511X-5-24.

[156] Oben, J. E., Enyegue, D. M., Fomekong, G. I., Soukontoua, Y. B. and Agbor, G. A. (2007). The effect of Cissus quadrangularis (CQR-300) and a Cissus formulation (CORE) on obesity and obesity-induced oxidative stress. *Lipids in Health and Disease*, *6* (1): 1-8. doi: 10.1186/1476-511X-6-4.

[157] Nash, R., Azantsa, B., Kuate, D., Singh, H. and Oben, J. E. (2019). The use of a stem and leaf Extract of Cissus quadrangularis (CQR-300) to reduce body fat and other components of metabolic syndrome in overweight participants. *The Journal of Alternative and Complementary Medicine*, *25* (1): 98-106. doi: 10.1089/acm.2018.0016.

[158] Ntchapda, F., Bonabe, C., Atsamo, A. D., Azambou, D. R. K., Fouda, Y. B., Djibrine, S. I., Seke E. Paul F. and Théophile, D. (2020). Effect of Extract of *Adansonia digitata* stem bark on the development of hypertension in L-NAME-induced hypertensive rat model. *Evidence-based Complementary and Alternative* Medicine, 2020. doi: 10.1155/2020/3678469.

[159] Bilanda, D. C., Dimo, T., Djomeni, P. D. D., Bella, N. M. T., Aboubakar, O. B. F., Nguelefack, T. B. and Kamtchouing, P. (2010). Antihypertensive and antioxidant effects of Allanblackia floribunda Oliv. (Clusiaceae) Extract in alcohol- and sucrose-induced hypertensive rats. *Journal of ethnopharmacology*, 128 (3), 634-640. doi: 10.1016/j.jep.2010.02.025.

[160] Bilanda, D. C., Dzeufiet, D. P. D., Bopda, A. M., Kamtchuoing, P. and Dimo, T. (2018). Allablanckia floribunda hypotensive activity on ethanol induced hypertension in rat. *The Journal of Phytopharmacol*ogy *7* (2): 146-151.

[161] Sonfack, C. S., Nguelefack-Mbuyo, E. P., Kojom, J. J., Lappa, E. L., Peyembouo, F. P., Fofié, C. K., Tsabang N., Nguelefack T. B. and Dongmo, A. B. (2021). The Extract from the stem bark of Garcinia lucida Vesque (Clusiaceae) exhibits cardioprotective and nephroprotective effects in adenine-induced chronic kidney disease in rats. *Evidence-Based Complementary and Alternative Medicine* 2021: 5581041. doi: 10.1155/2021/5581041.

[162] Etaga N. B., Nzekuie Q. S., Ayina A. C. N., Tchamadeu M. C., Mekoulou N. J., Bika L. C. E., Nde Z., Bilog N. C., Mbock A. J., Dongmo A. B. and Mandengue S. H. 2021a. Effects of some varieties of Ananas comosus on obesity and insulin resistance induced by oxidised palm oil and sucrose diet in albino rats. *International Journal of Food and Nutritional Science* 8 (1): 33-40. doi: 10.15436/2377-0619.21.3802.

[163] Etaga B. N., Selakong N. Q., Etoundi O. C. B., Mekoulou N. J., Bika L. C. E., Aicha D. N., Ngaha M. I., Bilog N. C., Bogning Z. C., Mbock A. J., Endougou E. A. M., Dongmo A. B., Bongue B., Mandengue S. H., Ayina A. C. N. 2021b. *Carica papaya's* varieties improved obesity, insulin resistance and atherogenic risk in rats fed with oxidised palm oil and sucrose diet. *International Journal of Nutrition and Food* Sciences, 10 (5): 108-116. doi: 10.11648/j.ijnfs.20211005.13.

[164] Miaffo, D., Poualeu, S. L. K. and Kamanyi, A. (2014). Antidiabetic activity of the methanol and acetone extracts of twigs of *Combretum molle* in dexamathasone induced-insulin resistance in rats. *World Journal of Pharmaceutical Sciences*, 955-965.

[165] Njomen, G. B., Kamgang, R., Soua, P. R., Oyono, J. L. and Njikam, N. (2009). Protective effect of methanol-methylene chloride extract of *Terminalia glaucescens* leaves on streptozotocin-induced diabetes in mice. *Tropical Journal of Pharmaceutical Research*, *8* (1): 19-26. doi: 10.4314/tjpr.v8i1.14708.

[166] Woumbo, C. Y., Kuate, D. and Womeni, H. M. (2017). Cooking methods affect phytochemical composition and anti-obesity potential of soybean (*Glycine max*) seeds in Wistar rats. *Heliyon*, *3* (8): e00382. doi: 10.1016/j.heliyon.2017.e00382.

[167] Nkeng-Asong, B., Fokunang, T. E., Borgia, N. N., Grace, M., Bathelemy, N., Yves, T. O., Ngudjoe E. M., Ndikum V. N., Ngadjui B. T. and Ntungwen, F. C. (2019). Pytochemical Characterization, evaluation of the anti-diabetic activity and acute toxicity of *Azadirachta indica* (Meliaceae) seeds oil in Wistar rat models. *Asian Journal of Research in Medical and Pharmaceutical Sciences*, 6 (4): 1-14. doi: 10.9734/ajrimps/2019/v6i430109.

[168] Zofou D. Z. D., Pascal F. P. T. M. F., Manfo T., Mofor C. T. M. C. T., Lum P. L. P., Nebangwa D. N. N. D. N. and Assob N. J. C. (2017). Antidiabetic and safety evaluation of Afya tea® (Extract of *Moringa oleifera* Lam.) in streptozotocin-rat model. *International Journal of Indigenous Herbs and Drugs*, 2 (5): 1-10.

[169] Mbouche F. M. J., Tatsadjieu N. L. and Ndjouenkeu, R. (2021). *Ipomea batatas* leaf powder from Cameroon: antioxidant activity and antihyperlipidemic effect in rats fed with a high-fat diet. *Journal of Lipids*, 2021: 5539878. doi: 10.1155/2021/5539878.

[170] Choumessi T. A., Nkwenti C. H. A., Soh D., Mbouh M., Atsamo A. D. (2021). Anti-obesity effects of the methanol extract of *Momordica foetida* (Cucurbitaceae) in male *Wistar* rats. *International Journal of Pharmacy and Pharmaceutical Sciences*, 13 (6): 31-35.

[171] Nyangono B. C. N., Ngangoum, R. C., Kuate, D., Ngondi, J. L. and Oben, J. E. (2012). Effect of *Guibourtia tessmannii* extracts on blood lipids and oxidative stress markers in triton WR 1339 and high fat diet induced hyperlipidemic rats. *Biology and Medicine*, 4 (1): 1-10. doi: 10.4172/0974-8369.1000152.

[172] Mbappe, F. E., Ebouel, F. L. E., Ella, F. A., Akamba, B. D. A., Nanhah, J. K., Gouado, I. and Ngondi, J. L. (2022). Effect of *Beilschmedia obscura* on the prevention of high fat/high sucrose diet induced metabolic syndrome on male Albino Wistar rats. *Metabolism* Open, 13: 100156. doi: 10.1016/j.metop.2021.100156.

[173] Ntchapda, F., Djedouboum, A., Talla, E., Dongmo, S. S., Nana, P., Adjia, H, Nguimbou R. M., Gaimatakon S., Njintang Y. N. and Dimo, T. (2015). Hypolipidemic and anti-atherogenic effect of Extract leaves of Ficus glumosa (Moraceae) in rats. *Experimental gerontology*, 62: 53-62. doi: 10.1016/j.exger.2014.12.015.

[174] Bopda, O. S. M., Longo, F., Bella, T. N., Edzah, P. M. O., Taïwe, G. S., Bilanda, D. C., Tom, E. N. L., Kamtchouing P. and Dimo, T. (2014). Antihypertensive activities of the Extract of *Kalanchoe pinnata* (Crassulaceae) in high salt-loaded rats. *Journal of ethnopharmacology*, *153* (2): 400-407. doi: 10.1016/j.jep.2014.02.041.

[175] Kamgang, R., Youmbi Mboumi, R., Foyet Fondjo, A., Fokam Tagne, M. A., Mengue N. G. P. R. and Ngogang Y. J. (2008). Antihyperglycaemic potential of the water–ethanol extract of *Kalanchoe crenata* (Crassulaceae). *Journal of Natural Medicines*, 62 (1): 34-40. doi: 10.1007/s11418-007-0179-y.

[176] Tuem, S. R., Ndomou, M., Manz, K. J. C., Nchoutpouen, N. M. and Gouado, I. (2021). Effect of aqueous and methanolic extracts of Solanum aethiopicum Linn Gilo (Solanaceae) leaves on body weight and Glycemia in rats with alloxan-induced diabetes. *Journal of Pharmacognosy and Phytochemistry*, 10 (5): 142-146.

[177] Ngueguim T. F., Massa Z. B., Kouamouo J., Tchuidjang A., Dzeufiet D. P. D., Kamtchouing P., Dimo T. (2014). Antidiabetic and antioxidant effects of *Annona muricata* (Annonaceae), Extract on streptozotocin-induced diabetic rats. *Journal of Ethnopharmacology*, 151 (2): 784-790. doi: 10.1016/j.jep.2013.09.021.

[178] Nkono, B. L. N. Y., Sokeng, S. D., Désiré, D. D. P. and Kamtchouing, P. (2014). Antihyperglycemic and antioxydant properties of *Alstonia boonei* De wild. (Apocynaceae) stem bark Extract in dexamethasone-induced hyperglycemic rats. *International* Journal of Diabetes *Research*, 3 (3): 27-35.

[179] Tazon, W. A., Fonkoua, M., Zali, M. A., Janvier, Y., Takuissu G. G., Makamwe, I. and Azantsa K. G. (2022). *In vitro* and *In vivo* evaluation of the anti-diabetic, anti-hyperlipidemic and antioxidant properties of Extract of Millettia laurentii bark (Fabaceae). *Journal of Medicinal Herbs*, 13 (1): 37-48. doi: 10.30495/MEDHERB.2022.692032.

[180] Miaffo, D., Ntchapda, F., Kamgue, O. G., Mahamad, A. T. and Kamanyi, A. (2020). Glucose-lowering potential of *Guiera senegalensis* roots in a diabetic rat model. *Avicenna Journal of Phytomedicine*, *10* (6): 653.

[181] Dimo, T., Azay, J., Tan, P. V., Pellecuer, J., Cros, G., Bopelet, M. and Serrano, J. J. (2001). Effects of the aqueous and methylene chloride extracts of Bidens pilosa leaf on fructose-hypertensive rats. *Journal of Ethnopharmacology*, *76* (3): 215-221. doi: 10.1016/S0378-8741(01)00229-X.

[182] Oumarou, B. A., Ndzana, M. B., Toma, E. N. L., Bilanda, D. C. and Dimo, T. (2012). Antihypertensive activity of *Jateorhiza macrantha* (Menispermaceae). Extract On Ethanol-Induced Hypertension In Wistar. *International Journal of Pharmacy and Pharmaceutical Sciences*, 4 (2): 293-298.

[183] Bilanda, D. C., Tcheutchoua, Y. C., Dzeufiet, P. D. D., Fokou, D. L. D., Fouda, Y. B., Dimo, T. and Kamtchouing, P. (2019). Antihypertensive Activity of *Leersia hexandra* Sw. (Poaceae) Extract on Ethanol-Induced Hypertension in Wistar Rat. *Evidence-Based Complementary and Alternative Medicine*, 2019: 2897867. doi: 10.1155/2019/2897867.

[184] Metchi D. M. F., Atsamo, A. D., Temdié Guemmogne, R. J., Ngouateu K. O. B., Dongmo, A. B. and Dimo, T. (2021). Antihypertensive effects of the *Vitex cienkowskii* (Verbenaceae) stem-bark extract on L-NAME-Induced hypertensive Rats. *Evidence-Based Complementary and Alternative Medicine*, 2021: 6668919. doi: 10.1155/2021/66689192021.

[185] Wansi S. L., Nyadjeu P., Ngamga D., Nguelefact M. E. P., Nguelefack T. B., Kamanyi A. (2007). Blood pressure lowering effect of the ethanol extract from the stem bark of *Cinnamomum zeylanicum* (Lauraceae) in rats. *Pharmacologyonline*, 3: 166-176.

[186] Nyadjeu, P., Nguelefack-Mbuyo, E. P., Atsamo, A. D., Nguelefack, T. B., Dongmo, A. B. and Kamanyi, A. (2013). Acute and chronic antihypertensive effects of *Cinnamomum zeylanicum* stem bark methanol extract in L-NAME-induced hypertensive rats. *BMC complementary and alternative medicine*, 13 (1): 1-10. doi: 10.1186/1472-6882-13-27.

[187] Nyadjeu, P., Dongmo, A., Nguelefack, T. B. and Kamanyi, A. (2011). Antihypertensive and vasorelaxant effects of Cinnamomum zeylanicum stem bark Extract in rats. *Journal of Complementary and Integrative* Medicine, 8 (1): 1-18. doi: 10.2202/1553-3840.1490.

[188] Ntchapda F., Barama J., Talla E. and Dimo T. (2017). Hypolipidemic, antioxidant and anti-atherosclerogenic effect of Extract leaves of C*assia occidentalis* Linn (Caesalpiniaceae) in diet-induced hypercholesterolemic rats. *BMC Complementary Medicine and Therapies*, 17: 76. doi: 10.1186/s12906-017-1566-x.

[189] Leudeu, B. C. T., Tchiégang, C., Barbé, F., Nicolas, B. and Guéant, J. L. (2009). *Ricinodendron heutelotii* (Bail.) or *Tetracarpidium conophorum* Müll. oils fed to male rats lower blood lipids. *Nutrition Research*, 29 (7): 503-509. doi: 10.1016/j.nutres.2009.07.004.

[190] Mvongo, C., Mfopa, A., Kamgang, R. and Essame Oyono, J. L. (2016). Antidiabetic and antioxidant activities of Crinum jagus extracts on induced diabetes rats MACAPOS 1. *International Journal of Pharmacology, Phytochemistry and Ethnomedicine*, *5*: 86-95.

[191] Tchouanka, B. T., Abega, G. R. A., Zebaze, L. J. J. G. and Nkono, B. L. N. Y. (2022). Extracts and fractions of *Gymnema sylvestre* restore liver and kidney function by regulating tissue and serum transaminases in the type 2 diabetic rat. *GSC Biological and Pharmaceutical Sciences*, 20 (1): 314-325. doi: 10.30574/gscbps.2022.20.1.0302.

[192] Teugwa, C. M., Mejiato, P. C., Zofou, D., Tchinda, B. T. and Boyom, F. F. (2013). Antioxidant and antidiabetic profiles of two African medicinal plants: *Picralima nitida* (Apocynaceae) and *Sonchus oleraceus* (Asteraceae). *BMC complementary and alternative medicine* 13 (1): 1-9. doi: 10.1186/1472-6882-13-175.

[193] Nyunaï N., Yaya A. J. G., Tabi N. T. G., Tchamgoue A. D., Ngondé M. C., Minka M. C. S. (2016). Anti-hyperglycemic and antioxidant potential of water-ethanol extract of *Musanga cecropioides* stem bark. *International Journal of Pharmaceutical Sciences and Drug Research*, 8 (1): 43-49.

[194] Tchamgoue, A. D., Tchokouaha, L. R., Tsabang, N., Tarkang, P. A., Kuiate, J. R. and Agbor, G. A. (2018). *Costus afer* protects cardio-, hepato- and reno-antioxidant status in streptozotocin-intoxicated wistar rats. *BioMed Research International*, 2: 4907648. doi: 10.1155/2018/4907648.

[195] Tchamgoue A., Dzeufiet P., Kuiata J. R., Agbor G. (2020). *Costus afer* modulates the activities of glycolytic and gluconeogenic enzymes in streptozotocin induced diabetic rats. *Journal of drugs delivery and therapeutics*, 10 (4s). doi: 10.22270/jddt.v10i4-s.4270.

[196] Noussi C., Ngueguim, F. T., Kamkumo G. R., Donfack G. C., Kandeda, A. K., Philippe D. J., Fifen R., Djomeni D. D. P., Ngouela S., Sewald N., Ndjakou L. B. and Dimo, T. (2020). Hydroethanolic extract from Bridelia atroviridis Müll. Arg. bark improves haematological and biochemical parameters in nicotinamide-/streptozotocin-induced diabetic rats. *Evidence-Based Complementary and Alternative Medicine*, 2020: 3160834. doi: 10.1155/2020/3160834.

[197] Tsafack, E. G., Mbiantcha, M., Ateufack, G., Djuichou Nguemnang, S. F., Nana Y. W., Atsamo, A. D., Mba V. M. M., Adjouzem C. F. and Ben B. E. (2021). Antihypernociceptive and Neuroprotective Effects of the Aqueous and Methanol Stem-Bark Extracts of *Nauclea pobeguinii* (Rubiaceae) on STZ-Induced Diabetic Neuropathic Pain. *Evidence-Based Complementary and Alternative Medicine*, 2021: 6637584. doi: 10.1155/2021/6637584.

[198] Takuissu, G. R., Fonkoua, M., Mandob, D., Ngoumen, D., Ambamba, D., Nanhah, J. and Judith, L. N. (2022). Subacute effects of hydroethanolic extracts of the pulp of *Gambeya africana* on glucose plasmatic levels and oxidative stress markers in diabetic rats. *Metabolism Open*, *14*: 100192. doi: 10.1016/j.metop.2022.100192.

[199] Kowa, T. K., Nyunaï, N., Tchamgoue, A. D. and Nkoulou, T. G. (2018). Antihyperglycemic and anti-oxidant potential of ethanol extract of *vitex thyrsiflora* leaves on diabetic rats. *Univ J Pharm Res*, *3* (3): 19-25.

[200] Medjiofack D. F., Cusinato, F., Ragazzi, E. and Froldi, G. (2021). α-Glucosidase and advanced glycation end products inhibition with *Vernonia amygdalina* root and leaf extracts: New data supporting the antidiabetic properties. *Journal of Pharmacy and Pharmacology*, *73* (9): 1240-1249.

[201] Teugwa, C. M., Boudjeko, T., Tchinda, B. T., Mejiato, P. C. and Zofou, D. (2013). Anti-hyperglycaemic globulins from selected Cucurbitaceae seeds used as antidiabetic medicinal plants in Africa. *BMC complementary and alternative medicine*, *13* (1): 1-8. doi: 10.1186/1472-6882-13-63.

[202] Palla N. C. L, Etoundi O. C. B and Gouado I (2015). Antiamylase potential of telfairia occidentalis leaves from Cameroon and effect of their dietary supplementation on fasting blood glucose in Wistar Rats. *Journal of Biosciences and Medicines* 3 (9): 59681. doi: 10.4236/jbm.2015.39010.

[203] Sokeng, S. D., Rokeya, B., Mostafa, M., Nahar, N., Mosihuzzaman, M., Ali, L. and Kamtchouing, P. (2005). Antihyperglycemic effect of Bridelia ndellensis ethanol extract and fractions in streptozotocin-induced diabetic rats. *African Journal of Traditional, Complementary and Alternative Medicines,* 2 (2): 94-102.

[204] Fomekong, G. I., Momo, C. E. and Oben, J. E. (2008). Antihyperglycemic and hypoglycemic effects of aqueous and hydroethanolic extracts of Pentaclethra macrophylla Benth on Wistar rats. *Medicinal and Aromatic Plant Science and Biotechnology*, *2* (1): 31-34.

[205] Maidadi, B., Ntchapda, F., Miaffo, D. and Kamgue Guessom, O. (2022). Efficacy of *Rytigynia senegalensis* blume on free radical scavenging, inhibition of α-amylase and α-glucosidase activity and blood glucose level. *Evidence-Based Complementary and Alternative Medicine*, 2022: 9519743. doi: 10.1155/2022/9519743.

[206] Dimo, T., Ngueguim, F. T., Kamtchouing, P., Dongo, E. and Tan, P. V. (2006). Glucose lowering efficacy of the aqueous stem bark extract of *Trema orientalis* (Linn) Blume in normal and streptozotocin diabetic rats. *Die Pharmazie-An International Journal of Pharmaceutical Sciences*, *61* (3): 233-236.

[207] Ndjenda II M. K., Nguelefack-Mbuyo, E. P., Atsamo, A. D., Fofie, C. K., Fodem, C., Nguemo, F. and Nguelefack, T. B. (2021). Antihypertensive Effects of the methanol extract and the ethyl acetate fraction from Crinum zeylanicum (Amaryllidaceae) leaves in L-NAME-Treated Rat. *Evidence-Based Complementary and Alternative Medicine*, (2021). doi: 10.1155/2021/2656249.

[208] Nguelefack, T. B., Fodem, C., Nguelefack-Mbuyo, E. P., Nyadjeu, P., Wansi, S. L., Watcho, P. and Kamanyi, A. (2015). "Endothelium nitric oxide-independent vasorelaxant effects of the Extract from *Stephania abyssinica* on the isolated rat thoracic aorta" *Journal of Complementary and Integrative* Medicine, 12 (1): 15-21. doi: 10.1515/jcim-2014-0022.

[209] Fodem, C., Nguelefack-Mbuyo, E. P., Ndjenda II, M. K., Kamanyi, A. and Nguelefack, T. B. (2021). Vasorelaxant-mediated antihypertensive effect of the leaf Extract from *Stephania abyssinica* (Dillon and A. Rich) Walp (Menispermaceae) in Rat. *BioMed Research International*, 4730341. doi: 10.1155/2021/4730341.

[210] Ntchapda, F., Bonabe, C., Kemeta Azambou, D. R., Talla, E. and Dimo, T. (2016). Diuretic and antioxidant activities of the Extract of leaves of *Vepris heterophylla* (Engl.) R. Let (Rutaceae) in rats. *BMC complementary and alternative medicine*, *16* (1): 1-10. doi: 10.1186/s12906-016-1439-8.

[211] Nguelefack, T. B., Mekhfi, H., Dongmo, A. B., Dimo, T., Watcho, P., Zoheir, J., Legssyer A, Kamanyi A. and Ziyyat, A. (2009). Hypertensive effects of oral administration of the Extract of Solanum torvum fruits in L-NAME treated rats: Evidence from *In vivo* and *In vitro* studies. *Journal of Ethnopharmacology*, *124* (3): 592-599. doi: 10.1016/j.jep.2009.04.057.

[212] Nguelefack, T. B., Mekhfi, H., Dimo, T., Afkir, S., Nguelefack-Mbuyo, E. P., Legssyer, A. and Ziyyat, A. (2008). Cardiovascular and anti-platelet aggregation activities of extracts from Solanum torvum (Solanaceae) fruits in Rat. *Journal of Complementary and Integrative Medicine*, 5 (1). doi: 10.2202/1553-3840.1105.

[213] Bopda, M. O. S., Dimo, T., Nguelefack, T. B., Dzeufiet, D. D., Rakotonirina, S. V. and Kamtchouing, P. (2007). Effects of *Brillantaisia nitens* Lindau (Acanthaceae) methylene chloride/methanol leaf extract on rat arterial blood pressure and heart rate. *Pharmacologyonline*, 1: 495-510.

[214] Bopda O. S. M., Dimo T., Tonkep I. S., Zapfack L., Djomeni D. Z., Kamtchouing P. (2011). Cardiodepression as a possible mechanism of the hypotensive effects of the methylene chloride/methanol leaf extract of Brillantaisia nitens Lindau (Acanthaceae) in rats. *African Journal of Biotechnology,* 10 (72): 16393-16401. doi: 10.5897/AJB11.2061.

[215] Tom E. N. L., Bopda, O. S. M., Monju, M. P., Bekono, Y. F., Mimb, J. R. B., Bilanda, D. C. and Dimo, T. (2021). *Kalanchoe pinnata* extract possesses vasorelaxant activities contributing to its antihypertensive effects in a model of rat-induced hypertension and myocardial infarction. *The Journal of Phytopharmacology*, 10 (5): 366-373. doi: 10.31254/phyto.2021.10515.

[216] Dimo, T., Azebaze, A. G. B., Kamgang, R., Rakotonirina, S. and Nkengfack, A. E. (2003). Vasodilator effect of the methylene chloride/methanol extract of *Erythrina indica* Linn (Leguminosae). *Journal of the Cameroon Academy of Sciences*, 3 (3): 207-212.

[217] Tsague M. V., Fokunang N. C., Talla E., Djekilamber A., Tembe-Fokunang E. A., Ngo Lemba T. E., Essomba C., Ntchapda F., Sokeng D. S., Oben J. E., Ze M. J., Afane E. A., Temdie G. R. J., Dimo T., Chi F. G., Ngadjui T. B. (2016). Identification of the bioactive compounds hypotensive effect in the ethyl acetate extract of *Eribroma oblongum* (Malvaceae) stem bark. *Journal of Diseases and Medicinal Plants* 2 (6): 74-82. doi: 10.11648/j.jdmp.20160206.13.

[218] Dongmo, A., Kamanyi, M. A., Tan, P. V., Bopelet, M., Vierling, W. and Wagner, H. (2004). Vasodilating properties of the stem bark extract of *Mitragyna ciliata* in rats and guinea pigs. *Phytotherapy Research: An International Journal Devoted to Pharmacological and Toxicological Evaluation of Natural Product Derivatives 18* (1): 36-39. doi: 10.1002/ptr.1350.

[219] Tiwo T. C., Womeni H. M., Ndomou H. S., Tchoumbougnang F., Momo F., Linder M. and Nayak B. (2018). Effects of boiled fish (*Silurus glanis, Heterotis niloticus, Cyprinus carpio* and *Oreochromis niloticus*) ingestion on the growth of young male and female Wistar albino rats. *Journal of Nutrition and Food Sciences*, 8 (652): 1000652. doi: 10.4172/2155-9600.1000652.

[220] Manz koule J. C., Ndomou M., Njinkoue J. M., Tchoumbougnang F., Milong M. C. S., Djimbie D. J., Soh O. A. V., Nchoutpouen M. N., Foumedzo R. and Gouado I. (2020). Antihyperlipidemic potential of oil extracted from *Ilisha africana* on rats. *Scientific African*, 8: e00322. doi: 10.1016/j.sciaf.2020.e00322.

[221] Nchoutpouen M. N., Ndomou M., Manz K. J. C., Milong C. S. M., Dama R. A., Ndombol N. R. P., Nsoga J. V. F., Ngo T. C., Youogo M. T., Peyieno M., Ngock E. and Tchoumbougnang F. (2020). Hypolipidemic effects of oil extracted from *Ethmalosa fimbriata* on dislipidemic female rats. *Int. J. Biol. Chem. Sci.* 14 (6): 2193-2203.

[222] Njiké N. F. H., Fowa A. B., Teboukeu G. B., Mouokeu, R. S. and Womeni, H. M. (2021). Effectiveness of boiled *Chrysicthys nigrodigitatus* against rats-induced *Salmonella Typhi* infection. *Clinical Nutrition Open Science*, *37*: 25-34. doi: 10.1016/j.nutos.2021.04.001.

[223] Kuate, D., Etoundi, B. C., Azantsa, B. K., Kengne, A. P. N., Ngondi, J. L. and Oben, J. E. (2010). The use of LeptiCore® in reducing fat gain and managing weight loss in patients with metabolic syndrome. *Lipids in Health and Disease*, 9 (1): 1-7. doi: 10.1186/1476-511X-9-20.

[224] Tiencheu, B., Achidi, A. U., Flore, T. N. E., Tenyang, N., Lyonga, A. N. M. and Romelle, F. D. (2021). Oils of Rhynchophorusphoenicis Larva and Brachytrupesmembranaceus: Chemical properties, fatty acid composition and its effects on serum lipid profile of Wistar albino rats. International Journal of *Innovative Research in Science, Engineering and Technology*, 10 (4): 329-340. doi: 10.15680/IJIRSET.2021.1004004.

[225] Mfopa A., Mediesse F. K., Mvongo C., Nkoubatchoundjwen S., Lum A. A., Sobngwi E., ´ Kamgang R. and Boudjeko T. (2021). Antidyslipidemic potential of water-soluble polysaccharides of *Ganoderma applanatum* in MACAPOS-2-Induced obese rats. *Evidence-Based Complementary and Alternative Medicine,* 2021: 2452057. doi: 10.1155/2021/2452057.

[226] Etoundi O. C. B., Kayo T. C. V., Mbang M. A. J. and Piéme C. A. (2019). Study of acute toxicity and the effect of the Extract of a formulation of three edibles mushrooms on oxidative stress induced in rats. *World Journal of Food Science and Technology*, 3 (1): 6-13. doi: 10.11648/j.wjfst.20190301.12.

[227] Etoundi O. C. B., Mbang M. A. J., Tuem S. and Gouado, I. (2017). Study of toxicity and antidiabetic activity of ethanolic and hydroethanolic extracts of Pleurotus pulmonarius and the Extract of Pleurotus floridanus. *Journal of Food, Nutrition and Population Health*, *1* (20).

[228] Etoundi, O. C. B., Kayo, V., Deudje, O. N., Djamen, B. M., Nangmou, M. N. and Azebaze, B. G. A. (2020). The influence of solvent nature on the extraction yield of *Pleurotus pulmonarius, Pleurotus floridanus* and *Pleurotus sajor-caju* and study of the effects of extract mixtures on oxidative stress. *Nutrafoods*, doi: 10.17470/NF-020-0027.

[229] Mbang M. A. J., Etoundi O. C. B., Djessissem R. and Kana, S. M. M. (2020). Evaluation of the activity of alpha amylase and antioxidant potential formulations of three varieties of oyster mushrooms: *Pulmonarius, floridanus and sajor-caju*. *Journal of the Cameroon Academy of Sciences*, 15 (3): 151-162. doi: 10.4314/jcas.v15i3.1.

[230] Mbang M. A. J., Kana S. M. M., Etaga N. B., Fandio M. K. and Etoundi O. C. B. (2021). Evaluation of toxicity, antihyperglycemic and hypoglycemic activities of mixtures of extracts of 3 varieties of Oyster mushrooms. *Food Science and Nutrition Research*, 4 (2): 1-8.

[231] Kanjo W. R., Njouonkou A. L., Yongabi A. K., Manfo T. F. P., Tume C., Nantia A. E. (2022). *In vitro* screening of the anti-diabetic activity of six species of edible termite associated mushrooms (*Termitomyces* spp.) from the Western Highlands of Cameroon. *Current Research in Environmental and Applied Mycology (Journal of Fungal Biology)*, 12 (1): 125–135. doi: 10.5943/cream/12/1/10.

[232] Bobga, P. T., Fossi, B. T., Taiwe, G. S., Nkanpira, K. T., Yolande, N. E., Ngwa, F. A., Toukam T. L. L., Yuwong W. B. and Ndip, L. M. (2022). Evaluation of the anti-diabetic potential of probiotic Lactobacillus fermentum (PRI 29) Isolated from Cameroonian fermented cow milk in alloxan induced diabetes type-1 mice model. *Saudi Journal of Pathology and Microbiology*, *7* (10): 381-393. doi: 10.36348/sjpm.2022.v07i10.001.

[233] Bemmo, U. L. K., Kenfack, C. H. M., Bindzi, J. M., Barry, R. B. and Ngoufack, F. Z. (2021). Viability and *In vivo* hypocholesterolemic effect of *Lactobacillus plantarum* 29V in local honey. *Journal of Advances in Biology and Biotechnology*, 24 (2): 24-33. doi: 10.9734/JABB/2021/v24i230199.

[234] Zambou N. F., Kaktcham P. M., Fonteh A. F., Guetiya W. R. and Sieladie D. V. (2013). Effects of inclusion of two probiotic strains isolated from "Sha'a", a maize-based traditionally fermented beverage on lipid metabolism of rabbits fed a cholesterol-enriched diet. *International Journal of Animal and Veterinary Advances*, 5 (2): 87-97.