

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

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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 encountering 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 phytochemicals 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 21st globally and 4th 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)			<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	Impaired fasting glucose or on high blood glucose treatment or T2DM diagnosis	≥150 mg/dL or on triglyceride treatment			≥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, broader 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].

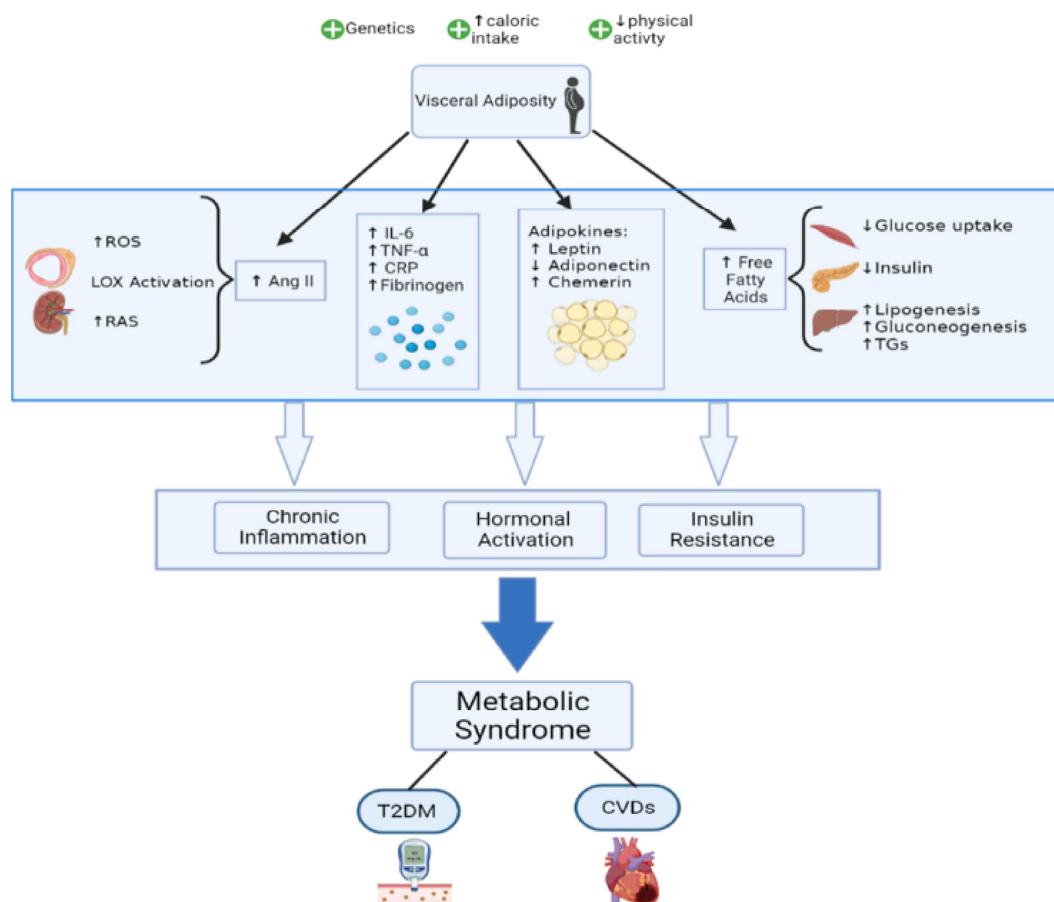


Figure 1. Mechanisms highlighting MetS pathophysiology [1].

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, adipisin, 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 status and 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 phytochemicals 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-1 β 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 monocolins 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 Bamiboutos 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 Fouban 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 21st globally and 4th 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 Nkoun-Khi division (West region). Also, Tsabang *et al.* reviewed the treatment of diabetes and/or hypertension using medicinal plants of Cameroon [66]; studied ethnomedicinal 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 Fouban 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 Lebaleme 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
<i>Obesity, dyslipidemia, diabetes and hypertension</i>		
Asteraceae	<i>Vernonia guineensis</i>	Roots
<i>Obesity, dyslipidemia and diabetes</i>		
Cucurbitaceae	<i>Zehneria scabra</i>	Whole plant, leaves
<i>Obesity, diabetes and hypertension</i>		
Annonaceae	<i>Annona muricata</i>	Leaves
	<i>Xylopia aethiopica</i>	Fruits
Apocynaceae	<i>Voacanga africana</i>	Fruits, bark, leaves
Bromeliaceae	<i>Ananas comosus</i>	Fruits
Convolvulaceae	<i>Ipomoea mauritiana</i>	Roots, starch
	<i>Alchornea cordifolia</i>	Leaves, roots
Euphorbiaceae	<i>Ricinodendron heudelotii</i>	Stem bark
Hypericaceae	<i>Harungana madagascariensis</i>	Roots, barks, leaves
Mimosaceae	<i>Tetrapleura tetraptera</i>	Bark, stem bark, fruits, seeds
Moraceae	<i>Ficus exasperata</i>	Bark, leaves
Solanaceae	<i>Solanum indicum</i>	Fruits
<i>Dyslipidemia, diabetes and hypertension</i>		
Anacardiaceae	<i>Anacardium occidentale</i>	Leaves, bark
Liliaceae	<i>Allium sativum</i>	Bulbs
	<i>Phyllanthus amarus</i>	Whole plant
Phyllanthaceae	<i>Phyllanthus niruri</i>	Whole plant
Solanaceae	<i>Solanum melongena</i>	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
<i>Obesity and dyslipidemia</i>		
Acanthaceae	<i>Brillantaisia vogeliana</i>	Leaves

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

Families	Species	Organs Used
	<i>Entandrophragma cylindricum</i>	Bark
	<i>Entandrophragma utile</i>	Trunk
	<i>Khaya ivorensis</i>	Bark
	<i>Lovoa trichiloides</i>	Bark
	<i>Azadirachta indica</i>	Seeds, leaves, bark
Mimosaceae	<i>Albizia zygia</i>	Roots bark
Mimosoideae	<i>Albizia ferruginea</i>	Bark
Monimiaceae	<i>Glossocalyx brevipes</i>	Leaves
Moraceae	<i>Treculia obovoidea</i>	Bark
Moringaceae	<i>Moringa oleifera</i>	Seeds, leaves
Myristicaceae	<i>Staudtia kamerounensis</i>	Seeds
Olacaceae	<i>Strombosia pustulata</i>	Bark
Olacaceae	<i>Strombosiopis tetrandra</i>	Bark
Passifloraceae	<i>Barteria fistulosa</i>	Leaves
Phyllanthaceae	<i>Bridelia micrantha</i>	Bark
Poaceae	<i>Zea mays</i>	Female flower, 'corn beard'
	<i>Crossopterys febrifuga</i>	Leaves
	<i>Hallea inermis</i>	
Rubiaceae	<i>Morinda lucida</i>	Fruits
	<i>Nauclea diderrichii</i>	Barks
	<i>Sarcocephalus latifolius</i>	Roots
	<i>Stipularia africana</i>	Leaves
	<i>Citrus aurantifolia</i>	Fruits
	<i>Citrus grandis</i>	Fruits
Rutaceae	<i>Citrus limon</i>	Fruits, leaves
	<i>Zanthoxylum heitzii</i>	Whole plant
	<i>Zanthoxylum tessmannii</i>	Bark
Sterculiaceae	<i>Sterculia tragantha</i>	Bark
Tiliaceae	<i>Corchorus olitorius</i>	Whole plant
Ulmaceae	<i>Celtis tessmannii</i>	Bark
Urticaceae	<i>Laportea ovalifolia</i>	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
<i>Obesity</i>		
Apocynaceae	<i>Mondia whitei</i>	Fruits, roots
Fabaceae	<i>Cajanus cajan</i>	Seeds
	<i>Irvingia gabonensis</i>	Seeds, bark
Irvingiaceae	<i>Irvingia wombolu</i>	Seeds
	<i>Sesamum indicum</i>	Leaves
Phyllanthaceae	<i>Hymenocardia acida</i>	Bark
Rubiaceae	<i>Galium asparine</i>	Whole plant
Solanaceae	<i>Solanum incanum</i>	Fruits
Zingiberaceae	<i>Aframomum melegueta</i>	Rhizomes
<i>Diabetes</i>		
Acanthaceae	<i>Asystasia gangetica</i>	Leaves
	<i>Eremomastax speciosa</i>	Leaves
Annonaceae	<i>Enantia chlorantha</i>	Bark
Apiaceae	<i>Apium graveolens</i>	Whole plant
Apocynaceae	<i>Holarrhena floribunda</i>	Bark
Araliaceae	<i>Panax ginseng</i>	Roots
Arecaceae	<i>Cocos nucifera</i>	Nuts
Asclepiadaceae	<i>Leptadenia hastata</i>	Roots
	<i>Spilanthes africana</i>	Whole plant
Asteraceae	<i>Vernonia amygdalina</i>	Leaves
Baselaceae	<i>Basella alba</i>	Whole plant
Bombacaceae	<i>Adansonia digitata</i>	Fruits
Brassicaceae	<i>Brassica oleracea</i>	Leaves
Caesalpiniaceae	<i>Senna apata</i>	Leaves
Caryophyllaceae	<i>Drymaria cordata</i>	Leaves, root
Chenopodiaceae	<i>Chenopodium ombrosoides</i>	Leaves
Clusiaceae	<i>Garcinia mangostana</i>	Bark
Combretaceae	<i>Terminalia catappa</i>	Leaves
Convolvulaceae	<i>Ipomoea batatas</i>	Leaves

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

Families	Species	Organs Used
Rutaceae	<i>Fagara macrophylla</i>	Bark
Solanaceae	<i>Solanum torvum</i>	Fruits
Sterculiaceae	<i>Pterygota bequaertii</i>	Bark
Thymaceae	<i>Theobroma cacao</i>	Fruits
Zingiberaceae	<i>Guiera senegalensis</i>	Roots, bark
	<i>Curcuma longa</i>	Rhizomes

Globally, these plants are grouped into 70 families, of which 35 are represented by at least 2 species. We have in particular Fabaceae 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, Glutiferaceae, 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
<i>Activities on obesity, dyslipidemia, diabetes, hypertension and with others benefits</i>				
Combretaceae	<i>Terminalia superba</i>	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	<i>Erythrina senegalensis</i>	Stem bark	Extract on diabetic hypertensive rats	[88]
Guttiferaceae	<i>Mammea africana</i>	Stem bark	Extract in hypertensive rats	[89]
			Extract in isolated aorta rings of the rat constricted	[90]
			Stem in diabetic rats	[91]
			Fruit pit extract associated to <i>Allium sativum</i> in rats with MetS	[92]
Lauraceae	<i>Persea americana</i>	Fruit pit,	Leaves extract associated to <i>Cymbopogon citratus</i> stems, <i>Citrus medica</i> fruits and honey in hypertensive rats	[87]
		Leaves, seeds	Leaves extract in diabetes rats and on <i>In vitro</i> activities of amylase and glycosidase	[93]
			Leaves extract on activities of enzymes relevant to carbohydrate/lipid digestion and cardio-metabolic diseases <i>In vitro</i>	[94]

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

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

Families	Species	Organs Used	Experiment	References
			diabetes rats	
Melanthaceae	<i>Bersama engleriana</i>	Leaves	Extract in diabetic rats	[138, 139]
Moraceae	<i>Dorstenia picta</i>	Twigs	Extract in diabetic rats	[140]
	<i>Ficus vallis-choudae</i>	Leaves	Extract in diabetic and obese rats	[141]
Musaceae	<i>Musa sapientum 'banane cochon'</i>	Fruits	Formulated biscuit in normal human subjects or formulated biscuit in association with <i>Vigna unguiculata</i> in diabetic rats	[122, 142]
Piperaceae	<i>Piper nigrum</i>	Leaves	Extract in rats under high fat diet	[143]
Portulacaceae	<i>Portulaca oleracea</i>	Leaves	Extracts associated with <i>Spilanthes africana</i> and <i>Sida rhombifolia</i> in diabetes rats	[116]
Rubiaceae	<i>Morinda lucida</i>	Stem bark	Extract in diabetic rats	[141, 144]
Rutaceae	<i>Fagara tessmannii</i>	Stem	Extract in obese rats	[145]
Sapotaceae	<i>Vitellaria paradoxa</i>	Bark	Extract in diabetic rats or in diabetic and obese rats	[146, 147]
Solanaceae	<i>Physalis peruviana</i>	Leaves	Extract and fractions in diabetics rats	[148, 149]
Tiliaceae	<i>Glyphaea brevis</i>	Leaves	Leaves extracts of <i>G.</i> in dyslipidemic and diabetic rats	[150]
Urticaceae	<i>Laportea ovalifolia</i>	Aerial part	Extract from aerial part on amylase activity or in diabetic rats	[85, 151]
Verbenaceae	<i>Clerodendrum thomsoniae</i>	Leaves	Extract in rats under high fat diet	[152]
	<i>Cissus polyantha</i>	Leafy stems, leaves	Leafy stems extract on <i>In vitro</i> amylase glucosidase activities and in diabetic rats	[153]
			Leaves extract from in diabetic rats	[154]
Vitaceae			Leaves extract (Cylaris™) in obese human subjects	[155]
	<i>Cissus quadrangularis</i>	Leaves and stem	Leaves extract (CQR-300) and formulation in obese human subjects	[156]
			Extract associated with <i>Irvingia gabonensis</i> in obese human subjects	[127]
			Leaves and stem extract in obese human subjects	[157]
Zingiberaceae	<i>Zingiber officinale</i>	Rhizomes	Extract in rats under high fat diet	[132]
	<i>Activities on obesity, dyslipidemia, hypertension and with others benefits</i>			
Bombacaceae	<i>Adansonia digitata</i>		Extract from stem bark in hypertensive rats	[158]
Clusiaceae	<i>Allablancikia floribunda</i>	Bark	Extract in hypertensive rats	[159, 160]
	<i>Garcinia lucida</i>		Extract in hypertensive rats	[161]
			Extract in <i>In vitro</i> activities of enzymes relevant to carbohydrate/lipid digestion and cardio-metabolic diseases	[98, 99]
	<i>Monodora myristica</i>	Seeds, roots	Extract on triglyceride accumulation and glucose uptake in SW 872 human adipocytes	[100]
			Extract on <i>In vitro</i> activities of enzymes relevant to carbohydrate/lipid digestion and cardio-metabolic diseases	[98, 99]
Annonaceae	<i>Xylopia aethiopica</i>	Fruits	Extract on triglyceride accumulation glucose uptake in SW 872 human adipocytes	[100]
			Extract on <i>In vitro</i> activities of enzymes relevant to carbohydrate/lipid digestion and cardio-metabolic diseases	[98, 99]
	<i>Xylopia parviflora</i>	Seeds/fruits	Extract on triglyceride accumulation glucose uptake in SW 872 human adipocytes	[100]
			Extract on <i>In vitro</i> activities of enzymes relevant to carbohydrate/lipid digestion and cardio-metabolic diseases	[98, 99]
Asteraceae	<i>Echinops giganteus</i>	Roots	Extract on triglyceride accumulation glucose uptake in SW 872 human adipocytes	[100]
			Extract on <i>In vitro</i> activities of enzymes relevant to carbohydrate/lipid digestion and cardio-metabolic diseases	[98, 99]
Huaceae	<i>Afrostryrax lepidophyllus</i>	Seeds, roots	Extract on triglyceride accumulation glucose uptake in SW 872 human adipocytes	[100]
			Extract on <i>In vitro</i> activities of enzymes relevant to carbohydrate/lipid digestion and cardio-metabolic diseases	[98, 99]
Zingiberaceae	<i>Aframomum melegueta</i>	Seeds, roots	Extract on triglyceride accumulation glucose uptake in SW 872 human adipocytes	[100]
	<i>Activities on obesity, dyslipidemia and diabetes</i>			
Bromeliaceae	<i>Ananas comosus</i>	Fruits	Juice in obese rats	[162]
Caricaceae	<i>Carica papaya</i>	Fruits	Juice in obese and diabetic rats	[163]
Combretaceae	<i>Combretum molle</i>	Twigs	Extract on diabetic rats	[164]
	<i>Terminalia glaucescens</i>	Leaves	Extract on diabetic mice	[165]
Fabaceae	<i>Glycine max</i>	Seeds	Powder in rats under high fat high sucrose diet	[166]
Meliaceae	<i>Azadirachta indica</i>	Seeds	Oil in diabetic rats	[167]
Moringaceae	<i>Moringa oleifera</i>	Leaves (Afy tea®)	Extract on diabetic rats	[168]
Zingiberaceae	<i>Aframomum daniellii</i>	Seeds	Extract from fruits on <i>In vitro</i> amylase, invertase and lipase activities	[98, 106]
	<i>Aframomum aulacocarpus</i>	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
<i>Activities on obesity and dyslipidemia with others benefits</i>				
Convolvulaceae	<i>Ipomoea batatas</i>	Leaves	Powder in rats under high fat diet	[169]
Cucurbitaceae	<i>Momordica foetida</i>	Roots, stem, leaves	Extract of mixture in obese rats	[170]
Fabaceae	<i>Guibourtia tessmannii</i>	Bark	Extract in rats under high fat diet	[171]
Lauraceae	<i>Beilschmedia obscura</i>	Seeds	Powder in rats under high fat/high sucrose diet	[172]
Moraceae	<i>Ficus glumosa</i>	Leaves	Extract in rats under high-cholesterol diet	[173]
<i>Activities on obesity and hypertension with others benefits</i>				
Crassulaceae	<i>Kalanchoe pinnata</i>	Leaves	Extract in high salt-loaded rats	[174]
<i>Activities on obesity and diabetes</i>				
Crassulaceae	<i>Kalanchoe crenata</i>	Leaves	Extract in diabetic rats	[175]
Solanaceae	<i>Solanum aethiopicum</i>	Leaves	Extracts in diabetes rats	[176]
<i>Activities on dyslipidemia and diabetes with others benefits</i>				
Annonaceae	<i>Annona muricata</i>	Leaves	Extract in diabetes rats	[177]
Apocynaceae	<i>Alstonia boonei</i>	Stem bark	Extract in diabetic rats	[178]
	<i>Millettia laurentii</i>	Bark	Extract in diabetic rats	[179]
Fabaceae	<i>Scorodophloeus zenkeri</i>	Bark, roots, seeds	Extract in <i>In vitro</i> 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]
Thymaceae	<i>Guiera senegalensis</i>	Roots	Extract on diabetic rats	[180]
Tiliaceae	<i>Triumfetta cordifolia</i>	Bark	Mucilage on rats under high fat diet	[129]
<i>Activities on dyslipidemia and hypertension with others benefits</i>				
Asteraceae	<i>Bidens pilosa</i>	Whole plant	Extracts from whole plant in hypertensive rats	[160, 181]
			Extract associated to <i>Cymbopogon citratus</i> in hypertensive rats	[104]
Menispermaceae	<i>Jateorhiza macrantha</i>	Leaves	Extract in hypertensive rats	[182]
Poaceae	<i>Leersia hexandra</i>	Whole plant	Extract in hypertensive rats	[183]
Rutaceae	<i>Zanthoxylum leprieurii</i>	Seeds	Extract on <i>In vitro</i> 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	<i>Vitex cienkowski</i>	Stem-bark	Extract in hypertensive rats	[184]
<i>Activities on dyslipidemia and hypertension</i>				
Lauraceae	<i>Cinnamomum zeylanicum</i>	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
<i>Activities on dyslipidemia with others benefits</i>				
Caesalpiniaceae	<i>Cassia occidentalis</i>	Leaves	Extract in rats with hypercholesterolemia	[188]
	<i>Ricinodendron heudelotii</i>			
Euphorbiaceae	<i>Tetracarpidium conophorum</i>	Seeds	Oil in normal rats	[189]
<i>Activities on dyslipidemia</i>				
Cyperaceae	<i>Scleria striatum</i>	Roots	Extract on <i>In vitro</i> amylase and lipase activities	[98]
<i>Activities on diabetes with others benefits</i>				
Amaryllidaceae	<i>Crinum jagus</i>	Whole plant	Extract on diabetic rats	[190]
	<i>Cathartus roseus</i>	Leaves	Extract in diabetes rats and on <i>In vitro</i> activities of amylase and glycosidase	[93]
Apocynaceae	<i>Gymnema sylvestre</i>	Leaves	Extract and fractions on diabetics rats	[191]
	<i>Picralima nitida</i>	Stem bark and leaves	Extract in diabetes mice	[192]
Asteraceae	<i>Sonchus oleraceus</i>	Whole plant	Extract in diabetes mice	[192]

Families	Species	Organs Used	Experiment	References
Cecropiaceae	<i>Musanga cecropioides</i>	Stem bark	Extract on diabetic rats	[193]
Costaceae	<i>Costus afer</i>	Whole plant	Extract of whole plant on digestive enzyme or in diabetic rats	[194]
Cucurbitaceae	<i>Luffa aegyptiaca</i>	Whole plant	Extract on amylase activity	[85]
Euphorbiaceae	<i>Bridelia atroviridis</i>	Bark	Extract in diabetic rats	[196]
Mirtaceae	<i>Eucalyptus globulus</i>	Leaves	Extract in diabetes rats and on <i>In vitro</i> activities of amylase and glycosidase	[93]
Rubiaceae	<i>Nauclea pobeguini</i>	Stem-bark	Extract on diabetic mice	[197]
Sapotaceae	<i>Gambeya africana</i>	Pulp	Extract in diabetics rats	[198]
Sterculiaceae	<i>Cola nitida</i>	Leaves, nuts	Extract on amylase activity	[85]
Verbenaceae	<i>Vitex thyrsoflora</i>	Leaves	Extract on diabetic rats	[199]
<i>Activities on diabetes</i>				
Asteraceae	<i>Vernonia amygdalina</i>	Leaves and roots	Extract on glucosidase activity and protein glycation	[200]
	<i>Cucurbita moschata</i>	Seeds	Globulins extracted on diabetic rats	
	<i>Citrullus lanatus</i>	Seeds	Globulins extracted on diabetic rats	
Cucurbitaceae	<i>Lagenaria siceraria</i>	Seeds	Globulins extracted on diabetic rats	[201]
	<i>Telfairia occidentalis</i>	Seeds	Globulins extracted on diabetic rats	
		Leaves	Extract of on diabetic rats and on <i>In vitro</i> activity of amylase	[202]
Euphorbiaceae	<i>Bridelia ndellensis</i>	Stem bark	Extract and fractions on diabetic rats	[203]
Hypericaceae	<i>Harungana madagascarensis</i>	Stem bark	Extract on amylase activity	[85]
Lauraceae	<i>Hypodaphnis zenkeri</i>	Bark	Extract on <i>In vitro</i> amylase and lipase activities	[98]
Mimosaceae	<i>Albizia sp</i>	Bark	Extract on amylase activity	[85]
	<i>Pentaclethra macrophylla</i>	Stem bark	Extract in rats and on <i>In vitro</i> activity of amylase	[204]
Moraceae	<i>Dorstenia psilurus</i>	Roots	Extract from roots on <i>In vitro</i> amylase and lipase activities	[98]
Piperaceae	<i>Piper umbellatum</i>	Leaves	Extract in <i>In vitro</i> activities of enzymes relevant to carbohydrate/lipid digestion and cardio-metabolic diseases	[94]
Rubiaceae	<i>Rytigynia senegalensis</i>	Leaves	Extract in amylase and glucosidase activities	[205]
Rutaceae	<i>Fagara lepreurii</i>	Seeds	Extract on <i>In vitro</i> amylase and lipase activities	[98]
	<i>Fagara xanthoxyloide</i>	Seeds	Extract on <i>In vitro</i> amylase and lipase activities	
Solanaceae	<i>Solanum melongena</i>	Fruits	Extract on <i>In vitro</i> amylase and lipase activities	[98]
Sterculiaceae	<i>Cola odorata</i>	Nuts	Extract on amylase activity	[85]
Ulmaceae	<i>Trema orientalis</i>	Stem bark	Extract in diabetic rats	[206]
<i>Activities on hypertension with others benefits</i>				
Amaryllidaceae	<i>Crinum zeylanicum</i>	Leaves	Extract and fractions in hypertensive rats	[90, 207]
Menispermaceae	<i>Stephania abyssinica</i>	Leaves	Extract on isolated aorta rings of the rat constricted and in hypertensive rats	[208, 209]
Rutaceae	<i>Vepris heterophylla</i>	Leaves	Extract on normal rats	[210]
Solanaceae	<i>Solanum torvum</i>	Fruits	Extract in isolated aorta rings of the rat constricted and in hypertensive rats	[211, 212]
<i>Activities on hypertension</i>				
Acanthaceae	<i>Brillantaisia nitens</i>	Leaves	Extract in hypertensive rats	[213, 214]
Crassulaceae	<i>Kalanchoe pinnata</i>	Leaves	Extract in hypertensive rats	[215]
Fabaceae	<i>Erythrina indica</i>	Stem bark	Extract in hypertensive rats	[216]
Malvaceae	<i>Eriobroma oblongum</i>	Stem bark	Extract in normal rats	[217]
Rubiaceae	<i>Mitragyna ciliata</i>	Stem bark	Extract in isolated aorta rings of the rat and Guinea pig constricted	[218]
Rutaceae	<i>Zanthoxylum heitzii</i>	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, Lauraceae, Malvaceae, Mimosaceae, Moraceae, Rubiaceae and Solanaceae with 4 species each. Combretaceae, Crassulaceae, Sapotaceae and Verbenaceae were represented by 3 species each. Those represented by 02 species were Amaryllidaceae, Anacardiaceae, Bombacaceae, Clusiaceae, Irvingiaceae, Lamiaceae, Laureanthaceae, 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 (*Chrysichthys 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 *Brachytripes 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	<i>Ilisha africana</i>	Oil from fish flesh in rats under high fat diet	[220]
Activities on obesity and dyslipidemia			
Clupeidae	<i>Ethmalosa fimbriata</i>	Oil from fish flesh in obese rats	[221]
Sciaenidae	<i>Pseudotolithus senegalensis</i>		[17]
Activities on dyslipidemia			
Cichlidae	<i>Oreochromis niloticus</i>	Fish flesh in normal rats	[219]
Cyprinidae	<i>Cyprinus carpio</i>		
Osteoglossidae	<i>Heterotis niloticus</i>		
Siluridae	<i>Silurus glanis</i>		
Claroteida	<i>Chrysichthys nigrodigitatus</i>	Fish flesh in rats infected with <i>Salmonella typhi</i>	[222]
Algae			
Activities on obesity, dyslipidemia, diabetes, hypertension and with others benefits			
<i>Aphanizomenonaceae</i>	<i>Aphanizomenon flosaquae</i>	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	<i>Brachytrupes membranaceus</i>	Oil from insects in rats under high fat diet	[224]
Activities on obesity and with others benefits			
Curculionidae	<i>Rhynchophorus phoenicis</i>	Oil from larvae in rats under high fat diet	[224]
MUSHROOMS			
Activities on obesity, dyslipidemia and with others benefits			
Ganodermataceae	<i>Ganoderma applanatum</i>	Polysaccharides extract on obese rats	[225]
Activities on dyslipidemia, diabetes and with others benefits			
Pleurotaceae	<i>Pleurotus floridanus</i> / <i>P. pulmonarius</i> / <i>P. sajor-caju</i>	Extracts from each species or from mixture in diabetic rats, rats fed with glucose, stressed rats, or in <i>In vitro</i> activities of amylase	[226-228, 230, 231]
Activities on dyslipidemia and diabetes			
Lyophyllaceae	<i>Termitomyces letestui</i> / <i>T. microcarpus</i> / <i>T. schimperi</i> / <i>T. aurantiacus</i> / <i>T. clypeatus</i> / <i>T. umkowaan</i>	Extract on <i>In vitro</i> activities of α -amylase, β -glucosidase, invertase and lipase	[232]
PROBIOTICS			
Activities on obesity, diabetes and with others benefits			
Lactobacillaceae	<i>Lactobacillus fermentum</i> PRI 29	Strain tested in diabetic mice	[233]
Activities on obesity and dyslipidemia			
Lactobacillaceae	<i>L. plantarum</i> 29V	Strain associated to honey in rats under high fat diet	[233]
	<i>L. plantarum</i> Lp10S / <i>L. plantarum</i> Lp11S	Strains tested <i>In vitro</i> for their capability to remove cholesterol and <i>In vivo</i> 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.

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