Nutritional Management Approach for Possible Prevention of COVID-19 Infection and Transmission in Sub-Saharan and Biodiversity Endowed Countries

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Authors’ contributions

This work was carried out in collaboration among all authors. Authors DJF, TEF, FCN, ERA, KNK and ATM designed the study. Authors NPN, TNN, BLT and EAES did data mining and organization. Authors NNB and LBF sorted information and wrote the first draft. All authors read and approved final draft.

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The causative etiology of the viral pneumonia outbreak in the Wuhan province of China in December 2019 initially identified as “novel-Coronavirus-2019” and today called “Corona Virus Disease-2019” has been identified as “severe acute respiratory syndrome coronavirus-2 (SARS-CoV-2)”. Tireless efforts have therefore been invested to elaborate a treatment and/or vaccine though with much controversy due to the lack of proper mastery of the structure, mode of action, mutation, recombination and transmission mechanism of the virus. Numerous public health measures have thus been imposed to slow down the rate of invasion and/or transmission (regular hand washing, face mask wearing, quarantine as well as method of diagnosis and symptomatic treatment) and now a convenient and acceptable treatment protocol and/or vaccine. With the difficulties encountered in the development of an effective and efficient control and/or preventive towards the virus even in the western world, countries in sub-Saharan Africa, especially those in the tropics like Cameroon will endure significant consequences due to limited funds, technology, equipment and experts. It is therefore imperative to exploit other possibilities as the recombination rate and mutation possibilities within the genome of SARS-CoV-2 is indicative that, the 2019 outbreak was just a tip of the iceberg as more virulent variants beyond Delta variants, are still to emerge. One of such suitable and affordable possibilities is to nutritionally fortify and prepared the body to fight against infection. Zinc, Copper and Selenium are essential micronutrients with demonstrated viral chelating activities found in selected commond foods which in adequate amounts will strengthen the immune system and tonify the body energy. A non-exhaustive list of common foods rich in the indicated micronutrients as well as those endowed with antioxidant and antimicrobial properties have been established from an extensive literature search in order to emphasize on the regular consumption.

Keywords: COVID-19 management; zinc, copper and selenium rich foods; antioxidant and antimicrobial foods; Subsaharan and Biodiversity endowe countries.

1. INTRODUCTION

The life ravaging viral pneumonia that emerged in the Wuhan province of China in December 2019 was identified as “novel-Coronavirus-2019” but is today called “Corona Virus Disease-2019” [1]. The causative etiology is attributed to a novel Human Coronavirus (HCoV) [2,3] that the International Committee of Taxonomy of Viruses (ICTV) decided to call “severe acute respiratory syndrome coronavirus-2 (SARS-CoV-2) on the 11th of February 2020 while the World Health Organization (WHO) named the disease “COVID-19” [4]. Human corona viruses were studied for the first time through the invitro propagation of nasal cavity isolates on human ciliated embryonic trachea cells [5]. The viruses were named “Coronaviruses” for the characteristic crown-like (solar corona) appearance produced by the peplomers of the spike [S] glycoproteins radiating from the virus lipid envelope [6]. Upon discovery, HCoVs was generally considered harmless until the SARS outbreak of 2003 which infected over 8,000 people globally [7]. The WHO declared the outbreak of covid-19, a Public Health Emergency of International Concern by 30 January 2020 [4]. That notwithstanding, the large disease outbreaks in multiple countries leading to more than 3,120 deaths and more than 91,000 infections by the 3rd of March 2020[8], pushed the WHO to raised it status and declared the outbreak, a pandemic on the 11th March 2020 [4].

In general, coronaviruses cause widespread respiratory, gastrointestinal, and central nervous system diseases in humans and other animals [9]; thereby threatening human health and causing economic losses [10]. It have been observed that about 14% of covid-19 patients develop severe disease that requires hospitalization and oxygen support while 5% require admission to an intensive care unit though it is common place to experience only mild or uncomplicated illness [11]. However, the complications of severe covid-19 cases include acute respiratory distress syndrome (ARDS), sepsis and septic shock, multiorgan failure (including acute kidney injury and cardiac injury) [12]. The contributing risk factors for such complications and subsequent death are older age and co-morbid disease, higher sequential organ failure assessment (SOFA) score and a d-dimer of more than 1 μg/L. In addition, the median duration to detect viral RNA is typically 20 days (interquartile range 17.0–24.0) while the maximum observed viral shedding duration was 37 days [13].
The public health measures recommended to manage the spread of the pandemic included: case isolation, identification and follow-up of contacts, disinfection of the environmental, and use of personal protective equipment [14]. In addition, the use of appropriate symptomatic treatment and supportive care for COVID-19 infected patients was endorsed [15].

Viral infection enhance the production of reactive oxygen species (ROS) generally, slow down the biosynthesis of major antioxidant enzymes as well as supports the increased production of reactive nitrogen species (RNS). Viral invasion therefore generates an oxidative/nitrosative stress which can enhance virus replication as well as the rate of the viral RNA genome mutation [16,17]. It can thus be concluded that since SARS virus in general and coronavirus in particular requires acidification of endosomes for proper functioning [18], an increase in the pH of intracellular compartments might play an important role in the inhibition of drugs during the treatment of SARS-CoV-2 infected patients [19].

As the current outbreak might only be the tip of an iceberg, with potentially more novel and severe zoonotic events to be revealed [20], it is therefore essential to seek an insight understanding of viruses particularly the crown viruses to provide at least preventive while studies to evaluate and ascertain the efficacy of ongoing treatments and vaccines conclude. While significant efforts are currently deployed towards the development of a confirmed effective and efficient specific antiviral treatment or vaccine, the recommended prevention is to avoid being exposed to the virus on the one hand [21] and on the other hand to tonify the body energy for protection and repose against viral invasion [22].

A convenient, reliable, available and affordable technique for a limited resource and low income country such as Cameroon blessed with a rich biodiversity resides in meeting and maintaining the Adequate Daily Allowance (ADI’s), recommended daily allowance (RDA’s) and Tolerable Upper Levels (TUL) of the viral chelating micronutrients. This can simply be achieved by regular consumption of common foods and herbs rich in Zn, Cu, and Se as well as foods with antimicrobial activities. From in vitro and some clinical studies, Zinc [23], Copper [24] and Selenium [20] have demonstrated considerable viral chelating properties. Although this paper is not claiming to provide a cure for the prevailing SARS-Cov-19, its main focus is to provide a non-exhaustive list of common herbs, fruits, vegetables and foods that can be used to top up the Zn, Cu and Se content of the body as well as natural antimicrobials (antibiotics) to fight microbes and antioxidants for possible oxidative stress.

2. BIOLOGY OF CORONA VIRUSES

2.1 Classification of Corona Viruses

The electron microscope illustration of the “corona”-like or crown-like morphology of SARS virus permitted the coining of the name “coronavirus” in 1968[25]. The International Committee on the Taxonomy of Viruses thereafter in 1975 created the Coronaviridae family which in 2005 during 10th International Nidovirus Symposium in Colorado, was divided into two subfamilies: the coronaviruses and the toroviruses[26]. The Coronaviridae family in addition to the Arteviridae, Roniviridae and Mesoniviridae families together forms the Nidovirales order[27]. While swine and equine pathogens represents members of the Arteviridae family, invertebrate viruses generally belong to the Roniviridae family[28, 29]. Based on genome sequence analysis[30], coronaviruses fall into three main genera (I to III) usually referred to as groups considering the demonstrated serological cross-reactivity [25].

The group I coronaviruses are:
- animal pathogens transmissible gastroenteritis virus (TGEV) of the pig, porcine epidemic diarrhea virus (PEDV), and feline infectious peritonitis virus (FIPV),
- human coronaviruses: HCoV-229E and HKU1.

The group II are:
- pathogens of veterinary relevance (BCoV, porcine hemagglutinating encephalomyelitis virus, and equine coronavirus),
- human coronaviruses viruses OC43 and NL63 and the mice and rats MHV.

The group III are:
- only avian coronaviruses (IBV, turkey coronavirus, and pheasant coronavirus [31].
The *Coronaviridae* family is the largest of the four families with a genomic size ranging from 26 to 32 kb [32].

2.2 Types of Human Corona Viruses

Based on genetic sequencing, it has been suggested that the virus is a betacoronavirus which presents a close relation to the SARS virus [11]. Advances in cryo-electron microscopy (cryo-EM) have elucidated the structure protecting most of the ectodomain of several coronavirus [S] proteins in their pre-fusion conformation leading to the description of the murine hepatitis virus (MHV) [33], human coronavirus (HCoV-NL63) [34], HCoV-HKU1[35], Middle East respiratory virus coronavirus (MERS-CoV) and severe acute respiratory syndrome coronavirus (SARS-CoV) [36,37]. All seven HCoVs have a zoonotic origin from bats, mice or domestic animals [38]. The coronavirus species recognized to cause disease in humans are: HCoV-229E, HCoV-OC43, HCoV-NL63, HCoV-HKU1, SARS-CoV and MERS-CoV [39,40].

2.3 Virion Morphology and Structure Coronaviruses

Coronavirus virions are spherical with diameters of approximately 125 nm as depicted by cryo-electron tomography and cryo-electron microscopy [33]. The most prominent feature of coronaviruses is the club-shaped spike projections emanating from the surface of the virion (Fig. 1).

Besides the prominence of the characteristic spikes, it is observed that all virions present all the envelope and N proteins; however, the HE is found only in some beta coronaviruses[41]. Also, it is believed that the interactions between the N proteins are responsible for the thronging together of the viral particles [42].

2.3.1 S Glycoproteins

The location of the [S] glycoproteins outside the virion confers to the virion the typical shape and the [S] proteins are responsible for the formation of homotrimers which on the one hand permit the development of a sun-like appearance from where is derived the Coronavirus name[43, 44]. The [S] proteins on the other hand through the C-terminal transmembrane regions bind to the virion membrane as well as interact with the M proteins [45]. The host cell, through the plasma membrane therefore present specific surface receptors with compatible N-terminus of the [S] proteins through which guarantee virions attachment [46].

![Fig. 1. Coronavirus virion structure shown with structural proteins. N: Nucleocapsid protein; S: Spike protein, M: Membrane protein, HE: Hemagglutinin-Esterase and E: Envelope protein [53]](image-url)
2.3.2 M Glycoproteins

M Glycoproteins poses three transmembrane regions. The glycosylation of the M proteins in the Golgi apparatus [47] is a crucial modification since it permits the fusion of virion into the cell on the one hand and on the other hand, it renders the protein antigenic [48]. The M proteins are key players in the process of cellular virion renewal [49].

2.3.3 E Glycoproteins

The E glycoproteins are minor proteins composed of approximately 76 to 109 amino acids amongst which about 30 of the amino acids in the N-terminus facilitates the attachment of viruses to the membrane [51]. In coronavirus, the E proteins also play a principal role in the assembly and morphogenesis of virions within the cell. Although [47] reported the possibility of coronavirus E and M proteins being expressed together with mammalian expression vectors to form virus-like structures within the cell [47], the significant decrease observed by [26] in the ability of the recombinant mouse hepatitis virus (MHV) and SARS viruses to elicit E protein expression in the genome fail to support this status [26].

2.3.4 N Proteins

The N proteins are phosphoproteins that have a flexible viral genomic RNA structure with helical binding potential. It contribute significantly to virion structure, replication and transcription of coronaviruses since the N protein is present in the replication/ transcriptional region of the coronaviruses and the ERGIC region where the virus is collected[52].

2.4 Coronavirus Life Cycle

All coronaviruses contain specific genes in Open Reading Frame (ORF)1 downstream regions that encode proteins for viral replication, nucleocapsid and spikes formation[54]. The glycoprotein spikes on the outer surface of coronaviruses are responsible for the attachment and entry of the virus to host cells (Figure 2). Table 1 presents the receptor-binding domain (RBD) which is usually loosely attached among virus, facilitating multiple hosts infection[55]. Other coronaviruses mostly recognize aminopeptidases or carbohydrates as a key receptor for entry to human cells while SARS-CoV and MERS-CoV recognize exopeptidases[56]. The entry mechanism of a coronavirus depends upon cellular proteases which include, human airway trypsin-like protease (HAT), cathepsins and transmembrane protease serine 2 (TMPRSS2) that split the spike protein and establish further penetration changes[57, 58]. MERS-coronavirus employs dipeptidyl peptidase 4 (DPP4), while HCoV-NL63 and SARS-coronavirus require angiotensin-converting enzyme 2 (ACE2) as a key receptor[56]. SARS-CoV-2 possesses the typical coronavirus structure with spike protein and also expressed other polyproteins, nucleoproteins, and membrane proteins, such as RNA polymerase, 3-chymotrypsin-like protease, papain-like protease, helicase, glycoprotein, and accessory proteins[59]. The spike protein of SARS-CoV-2 contains a 3-D structure in the RBD region to maintain the van der Waals forces[60]. The 394-glutamine residue in the RBD region of SARS-CoV-2 is recognized by the critical lysine 31 residue on the human ACE2 receptor[61]. Fig 2 presents the entire mechanism of pathogenicity of SARS-CoV-2, from attachment to replication. Illustration of some coronavirus receptos are well documented in Table 1.

2.5 Mutation and Genetic Recombination in Coronaviruses

Unlike other single-stranded RNA (ssRNA) viruses, the mutation rates in CoV arde estimated to range from moderate to high with about 10⁴ substitutions per year per site as mean substitution rate [64]. For example, the S gene nucleotide mutation rate of the hypervariable region is estimated at 0.3–0.6 x 10⁻² per site per year for IBV [65] and that for the S gene of 229E is approximately 3 x 10⁻⁴ substitutions per year per site [66]. The mutation rate in the whole genome of SARS-CoV is 0.80–2.38 x 10⁻³. However, a nonsynonymous and synonymous substitution rates which is identical to that of other RNA viruses were estimated to be 1.16–3.30 x 10⁻³ and 1.67–4.67 x 10⁻³ respectively for the SARS-CoV[66]. In addition, the size of the CoV’s RNA genome permits an extra plasticity during genome modification by mutations and recombinations. This adaptation, besides enabling the novel CoVs to emerge under the right conditions, increases the probability for intraspecies variability, interspecies ‘host jump’.
Fig. 2. The life cycle of SARS-CoV-2 in host cells begins when S protein binds to the cellular receptor ACE2. After receptor binding, the conformation change in the S protein facilitates viral envelope fusion with the cell membrane through the endosomal pathway. Then SARS-CoV-2 releases RNA into the host cell. Genome RNA is translated into viral replicase polyproteins pp1a and 1ab, which are then cleaved into small products by viral proteinases. The polymerase produces a series of subgenomic mRNAs by discontinuous transcription and finally translated into relevant viral proteins. Viral proteins and genome RNA are subsequently assembled into virions in the ER and Golgi and then transported via vesicles and released out of the cell. ACE2, angiotensin-converting enzyme 2; ER, endoplasmic reticulum; ERGIC, ER–Golgi intermediate compartment [62]

Table 1. Coronavirus receptors

<table>
<thead>
<tr>
<th>Virus</th>
<th>Receptor</th>
<th>References</th>
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<tr>
<td><strong>Alphacoronaviruses</strong></td>
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<tr>
<td>HCoV-229E</td>
<td>APN</td>
<td>Yeager et al., 1992</td>
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<tr>
<td>HCoV-NL63</td>
<td>ACE2</td>
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<td>TGEV</td>
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<td>Delmas et al., 1992</td>
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<tr>
<td>PEDV</td>
<td>APN</td>
<td>Li et al., 2007</td>
</tr>
<tr>
<td>FIDV</td>
<td>APN</td>
<td>Tresnan et al., 1996</td>
</tr>
<tr>
<td>CCoV</td>
<td>APN</td>
<td>Benbacer et al., 1997</td>
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<td><strong>Betacoronaviruses</strong></td>
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<tr>
<td>MHV</td>
<td>mCEACAM</td>
<td>Nedellec et al., 1994; Williams et al., 1991</td>
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<td>BCoV</td>
<td>N-acetyl-9- O-acetylneuraminic acid</td>
<td>Schultze &amp; Herrler, 1992</td>
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<tr>
<td>SARS-CoV</td>
<td>ACE2</td>
<td>Li et al., 2003</td>
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<tr>
<td>MERS-CoV</td>
<td>DPP4</td>
<td>Raj et al., 2013</td>
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3. HUMAN CORONAVIRUS INFECTION

3.1 Route of Transmission

Although aerosol transmission constitute another route, droplets and close contact are the commonest SARS-CoV-2 routes of transmission. SARS-CoV-2 has also been detected in stool, gastrointestinal tract, saliva and urine. In addition, bioinformatics evidence indicated that the digestive tract may be a route of SARS-CoV-2 infection [67]. Researchers have reported that SARS-CoV-2 RNA was consistently found in the gastrointestinal tissue of COVID-19 patients [68] while the tears and conjunctival secretions of COVID-19 patients contained the SARS-CoV-2 [69].

3.2 Pathogenicity of Human Coronaviruses

Coronaviruses were thought to only cause mild, self-limiting respiratory infections in humans prior to the SARS-CoV outbreak. The viruses are endemic to the human population responsible each year for 15–30 % of respiratory tract infections. The most vulnerable to SARS-CoV have been reported to be the neonates, the elderly, and individuals with underlying illnesses in which there is greater incidence of lower respiratory tract infection. It has been indicated that HCoV-NL63 is associated with acute laryngotracheitis [54]. Interestingly, human coronaviruses are differentially tolerant to genetic variability which is illustrated by the trifling sequence divergence of the HCoV-229E isolates around the world [70]. However, HCoV-OC43 isolates from the same location isolated in different years show significant genetic variability [71].

3.3 Relationship between Viral Pathogenicity and Transmissibility

The severity of disease is most often an important indirect factor in a virus’s ability to spread. The presence of an error-prone RNA-dependent RNA polymerases (RdRP) in coronaviruses impose frequent mutations and recombination events [72]. This result in a quasi species diversity that is narrowly associated with adaptive evolution and the capacity to cause disease. Previous studies have shown that SARS-CoV mutated from 2002 to 2004 improving the binding to the cellular receptor and replication in human cells which have enhanced the virulence. It is thus important to examine whether 2019-nCoV behaves like SARS-CoV to adapt to the human host and whether this would increase the R0 value and change its virulence. Since ACE2 (the receptor protein of both SARS-CoV and 2019-nCoV) is abundantly present in humans in the epithelia of the lung and small intestine [73], and coronaviruses can infect the upper respiratory and gastrointestinal tract of mammals, identifying the possible route of infection therefore might impact the pathogenesis and hence the treatment of disease caused by 2019-nCoV. It is evident that airborne viruses present higher R0 value compared to contact viruses and the trend indicates that higher pathogenicity is often associated with lower transmissibility and this may also apply to a certain virus of different subtypes and strains (influenza virus).

4. PREVENTION AND CONTROL (TREATMENT) of novel Human Corona Virus

4.1 Prevention

4.1.1 Personal hygiene

To decrease the diffusion of coronavirus, prior identification, isolation and observing social-distancing in crowded areas are crucial[74]. Different health instruction have been provided in communities by WHO to create awareness of epidemic control and prevention i.e., regular handwashing with soap and water at intermittent intervals or frequent cleaning with alcohol-based sanitizers as well as quarantine, to avoid crowded places and to limit or avoid contact with diseased persons.

4.1.2 Countrywide lockdown

Countrywide lockdowns have been implemented in various countries for specific periods to hamper the wild spread of the pandemic [1].

4.1.3 Daily fever surveillance

Temperature screening checkpoints have been arranged to screen all travelers by using thermal scanners at railway stations, subway stations, seaport and airport terminals in an attempt for identifying suspected people with fever in general [1].

4.1.4 Telemedicine

Hospitals are recommending online advisories and medical facilities to suspected and
symptomatic patients, which facilitates promoting awareness to the general public to avoid rushing to hospitals, thereby avoiding crowds or mass-gatherings in the hospitals, to prevent further transmission and thus decrease the possibility of being infected. To prevent health care employees from being infected, the National Health Commission (NHC) guaranteed adequately providing Personal Protective Equipments (PPEs) like isolation gowns, masks and gloves and issued a methodological guideline for the control and prevention of disease caused by the novel coronaviruses [1].

4.1.5 Isolation/Quarantine

Isolation/Quarantine is a conventional but very effective and successful measure to counteract all lethal epidemics, but isolation/quarantine practices can be hard to implement. To prevent community transmission, travelers from China (particularly Wuhan) and other cities/countries affected with COVID-19 were advised to report their travel history and advised to self-isolation for 14 days. Furthermore, both the confirmed and suspected cases should be immediately isolated and treated in the designated hospitals in efficient isolation (facility-based quarantine) and defensive conditions to avoid further transmission of infection to others [75].

4.1.6 Social distancing

Social distancing means literally 'physical distancing', i.e., to maintain a distance of three feet is believed to be a proper distance for people to stay away from an infected patient and everyone should strictly follow the social distance (at least 1 m) to reduce the risk of disease transmission [76].

4.1.7 Ban on wildlife market (live/dead)/bushmeat

The highly contagious pathogens of SARS and COVID-19 are said to originate from wild animals [77]. Besides, consumption, commercialization and game chasing for bushmeat dangerously distort the ecological balance and lead to the transmission of emerging and/or re-emerging highly infectious zoonotic diseases [78]. Consequently, is not only restricted to sell, chase and consume wild games but the interactions and encounters with wildlife can also be a potential threat which can be part of a religious or social practice, tourism or unavoidable encroachment of human population to the wild ecologies and the destruction of wild animals habitats due to human population explosion. Therefore, banning all wildlife markets either live or killed will be an efficient measure to prevent exotic viral infections of public health concern [79].

4.1.8 Vaccination

An effective vaccine is the need of the hour to render immunity against COVID-19. Vaccination is essential for control and treatment of epidemics/pandemics caused by these emerging and re-emerging exotic and highly infectious viral etiologies. Laudable efforts are being allocated globally by research institutions and pharmaceutical companies to manufacture a potential and acceptable vaccine for coronaviruses protection. The onset of the development and manufacture of such injection was the isolation from infected patients of the viral strains responsible for the prevailing pandemic [1].

4.2 Existing Sars-cov-2 Management/Treatment

4.2.1 Need based therapy to alleviate symptoms (symptomatic therapy)

There is no specific/standard antiviral treatment available for COVID-19, though some trial vaccine is currently available. However, symptomatic and oxygen therapy represents the major treatment approach for severely infected patients. The specific approach towards septic shock essentially requires hemodynamic assistance for managing septic shock while it might be important to engage mechanical ventilation in cases of respiratory failure refractory to oxygen therapy. WHO released a technical document summarizing the guidelines and scientific evidence derived from the treatment of previous HCoVs epidemics on January 28, 2020 [80].

4.2.2 Host immune modulation

Host response to SARS-CoV-2 infection is complex and highly dynamic. During initial exposure to SARS-CoV-2, there exist an effective initial host defense in the lungs of individuals which are associated with mild symptoms and disease resolution. In a few cases, viral evasion of the immune response can lead to refractory alveolar damage, ineffective lung repair mechanisms and systemic
inflammation with associated organ dysfunction [81].

4.2.3 Viral clearance

The most effective way for the treatment of SARS, MERS and COVID19 is to investigate whether existing antiviral drugs are efficient. In earlier epidemics of β-coronavirus, the investigated anti-viral drugs that produced some confirm promising in vitro outcomes were interferons (IFNs), darunavir/cobicistat (prezincobix), ribavirin and lopinavir-ritonavir [82].

4.2.4 Antivirals

Presently, for COVID-19 therapy, the antiviral efficacy of accepted drugs (penciclovir, ribavirin, chloroquine, nafamostat, umifenovir, darunavir, arbidol and nitazoxanide) in vitro are compared with that of favipiravir and remdesivir (broad-range antiviral medicines). Among the investigated drugs, chloroquine and remdesivir have been observed to be efficient for COVID-19 treatment [83] despite the established side effects of chloroquine.

4.2.5 Anticoagulants as therapeutics heparin

Low molecular weight heparin (LMWH) is the most commonly used anticoagulant as a COVID-19 remedy. Heparin is implicated in the binding activities of the CoVID-19 spike proteins and in the down regulation of interleukin-6 observed to be usually high in CoVID-19 patients[84].

4.2.6 Dipyridamole

Dipyridamole (DIP), an antiplatelet agent, acts as a phosphodiesterase (PDE) inhibitor that increases intracellular cAMP/cGMP [85]. In addition to this, DIP manifest the activities of a broad spectrum antiviral typically against positive-stranded RNA virus which could deliver potential therapeutic benefits to CoVID-19[86].

4.2.7 Use of ACE2 inhibitors

Since ACE2 receptors are essential for the virus to infest the host cell, it can be deduced that the successful inhibition of ACE2 receptors might restrict invivo virus replication. However, though selective ACE2 inhibitor, (trifluoroacetate salt DX600), may show favourable results during SARS-CoV-2 infection, clinical significance studies are imperative for conclusion [87].

5. NUTRITIONAL CONTRIBUTION TOWARDS TONIFICATION OF BODY ENERGY AND STRENGTHENING OF THE IMMUNE SYSTEM

The debate on the influence of nutrition on public health led to a consensus definition of “sustainable diets” as “diets with low environmental impacts that contribute to food and nutrition security and to healthy lives for present and future generations” [88].

5.1 Biology of Zinc, Copper and Selenium

5.1.1 Zinc

Zinc is the second most abundant trace metal in the human body( 2-3g) of which 90% is found in muscle and bone while the remaining 10% in other organs (including prostate, liver, the gastrointestinal tract, kidney, skin, lung brain, heart, and pancreas) where cellular zinc contributes to an efficient homeostatic control that avoids accumulation of zinc in excess [89]. Zinc plays a significant role in numerous aspects of cellular metabolism [90]. It has been estimated that about 10% of human proteins have the potential to bind zinc while hundreds exist that can transport and traffic zinc. Zinc is required for the catalytic activity of more than 200 enzymes [91] and it plays a role in immune function [92], wound healing [93], protein synthesis, DNA synthesis and cell division [94]. Zinc is required for proper sense of taste and smell [95] and supports normal growth and development during pregnancy, childhood, and adolescence [96]. Even at low concentrations, zinc ions are effective against microbial agents permitting the intense attenuation of gastroenteritis by zinc ingestion [98].

5.1.2 Copper

Copper plays an important role in metabolism, largely because it allows many critical enzymes to function properly. Copper contributes in conserving the strength of the skin, blood vessels, epithelial and connective tissue in the body. Copper plays a role in the production of hemoglobin, myelin, melanin and it also keeps thyroid gland functioning normally[99]. Copper can act as both an antioxidant and a pro-oxidant.

As an antioxidant, Cu scavenges or neutralize free radicals and may moderate or support the prevention of some of the damage they cause
As a pro-oxidant, sometimes copper promotes free radical damage which contribute to the development of Alzheimer's disease[102]. The maintenance of a proper dietary balance of Copper along with other minerals like zinc and manganese is therefore essential[100].

5.1.3 Selenium

Selenium is an essential trace element in the human body considering the anti-oxidative and pro-oxidative potentials as well as the significant implication in nourishment and medicine. Se uphold the narrowest range between dietary deficiency (40 g/day) and toxic levels (400 g/day). Selenium is important in cellular metabolism and is an essential component of the enzymes protecting the body against free radical species. Se has an important role in the metabolism of thyroid, human fertility and many other vital functions[103] and a number of stable organic compounds from Se are used as antioxidants, enzyme inhibitors, anti-tumor, anti-infective agents, cytokine inducers and immunomodulators have been synthesized[104]. The range of daily selenium intake varies between (7-4990) mg[105] though such extreme values are associated with signs of overt selenium deficiency and toxicity respectively, as reported from regions in China with very low as well as very high selenium content in the soil[106].

The recommended adequate intake amounts for selenium in adults range between 25 and 100 mg/d[107], with an average of 60 mg/d for men and 53 mg/d for women[105] while 300–450 mg/d is set as the tolerable upper intake level[106].

5.2 Antiviral Potentials of Zinc, Copper and Selenium Micronutrients

5.2.1 Zinc

Zinc participates in many metabolic and chronic diseases (diabetes, cancer, neurodegenerative diseases) and Zinc deficiency have been strongly associated to several other infections such as malaria, HIV, tuberculosis, measles, and pneumonia. ZIP and ZnT are tissue specific and present developmental and stimulus responsive expression patterns in Zinc homeostasis[108]. Zinc induced anti-virus activity could be enhanced for Tcell division, maturation and differentiation, lymphocyte response to mitogens, programmed cell death of lymphoid and myeloid origins, gene transcription, and biomembrane function[109].

5.2.2 Selenium

The impact of selenium on health and disease, dietary selenium requirements for support of cognitive and immune functions as well as cancer prevention and the corresponding underlying molecular mechanisms have been under studies[110]. In addition to selenium, several trace elements (e.g., copper, iron, zinc) and vitamins (e.g., vitamins A, C, and E) may modulate the susceptibility of hosts to pathogens and the immune defense against microbes[111].

5.2.3 Copper

Copper concentrations as low as 0.16 to 1.6 mM have demonstrated the ability to destroy viruses of great medical importance including influenza and human immunodeficiency virus (HIV). This is confirmed by the efficient elimination the risk of HIV transmission through fluids by copper[112]. The mechanisms supporting the antiviral activity involves the inactivation of a protease enzyme important for viral replication and damage at the phospholipid envelope level[113]. Numerous findings have illustrated the antiviral potentials of copper against pathogenic viruses; Infectious Bronchitis Virus[24], Influenza A[114], Coxsackie Virus Types B2 & B4[115], Human Immunodeficiency Virus[112], Infectious Bronchitis Virus[24], Measles and Parainfluenza 3 and Respiratory Syncytial Virus[116] and Poliovirus[117].

5.3 Common Plants Rich in Zinc, Copper and Selenium and/or Possessing Antimicrobial and Antioxidant Activities

5.3.1 Aloe Vera

Aloe vera (Aloe barbadensis Miller) is a perennial plant of the Xanthorrhoeaceae family. A. vera has been used for many centuries for its curative and therapeutic properties and although over 75 active ingredients from the inner gel have been identified [118]. Aloe vera also contains potentially active constituents, such as vitamins, enzymes, minerals, sugars, lignin, saponins, salicylic acid, and amino acids[119]. Due to its therapeutic and functional properties and hence its beneficial effects to humans, the use of aloe vera in the formulation of food products has steadily increased[120]. The mineral composition
of A. vera have been studied. Sanjay[121] determined the vitamin C content. Other researchers reported considerable antimicrobials activities of the peels and gel [122] while the antioxidant activities evaluated were respectively 16.2%, 2.43 ± 0.14(μmol TE g−1), 34.32 ± 2.60(μmol TE g-1), and 3.82 ± 0.23(μmol Fe II g-1) for PEE, DPPH, ABTS and FRAP respectively [123].

5.3.2 Avocado (Persea americana)

Persea americana peels, fruit and leaves are commonly used in America, Antilles and Africa for the treatment of various diseases such as menorrhagia, hypertension, stomach pain, bronchitis, diabetes and heart disease [124]. The reported micronutrient content was 0.42-0.68mg for Zinc, 0.17-0.262 mg for Copper [125] and 0.4μg of selenium [126]. The Vitamin C content indicated range from 7.9-8.8mg[125, 126]. Antimicrobial activities of the methanolic extract of the avocado green pulp against Mycobacterium tuberculosis have been reported resulting in a minimum inhibitory concentration of 15 μg/mL [127]while Leite et al.[128] indicated that the methanolic extract had antimicrobial action in the planktonic culture strains of Candida spp., Cryptococcus neoformans, and Malassezia pachydermatis. In addition, derived peptides from Avocado demonstrated antimicrobial activities on Escherichia coli, S. aureus[129]. The antioxidant activities of extracts of the common Avocado varieties such Hass, Quintal, Fortuna and Margarida species ranged between 21.28 ± 0.91 - 38.94 ± 0.58(μmol TE g-1) for DPPH, 0.06 ± 0.02 - 0.18 ± 0.01 for AAI, 2.34 ± 0.21-9.22 ± 0.17(μmol TE g-1) for ABTS and 3.62 ± 0.15-8.58 ± 0.09(μmol de Fe II g-1) for FRAP [130].

5.3.3 Banana (Musa sapientum)

Musa sapientum nutritional value of banana makes it useful for weight gain as well as weight loss, constipation, bowel problems, anemia, blood pressure, heart problems, ulcers, brain stimulation, depression, nervous disorders, stress and morning sickness. Banana is reported to have a Zinc content of 0.16mg, Copper of 1.104mg and vitamin C content of 9.1mg [125]. The antimicrobial capacity have been elucidated by ethanolic extract at 1025mg/ml which inhibited klebsiella pneumoniae with a 24mm inhibition zone while an MIC of 16 g/ml is reported effective for Salmonella typhi and 512.5 g/ml for Bacillus subtilis and Staphylococcus aureus [131].

Actioxidant potentials could be inferred from the Ascobic acid and citric acid contents of 0.84c ± 0.01 and 0.90 ± 0.04 respectively [132].

5.3.4 Beans (Phaseolus vulgaris)

Phaseolus vulgaris L. Common beans are often a main source of protein, dietary fiber and minerals in diet, occupying a very important worldwide place in human alimentation, offering benefits for human health. Bean contain high concentrations of health-promoting nutrients and thus consuming more beans in diet could improve overall health and also decrease the risk of developing certain diseases, including heart disease, obesity and many types of cancers [133]. The 2010 Dietary Guidelines for Americans recommend consuming 1.5 cups of beans per week to take advantage of this potential health benefits [134]. The Zinc of beans is 17.81- 37.90 mg/kg in the wild race and 25.03- 35.1 mg/kg for modern race while the selenium content generally range between 0.15-1.44mg/kg [135].

5.3.5 Bitterleaf (Vernonia amygdalina)

Vernonia amygdalina is a very important protective food and useful for the maintenance of health and prevention and treatment of various diseases. The chemical constituents of bitter leaf herb possess a potent anti-parasitic, anti-tumour, and bactericidal effect and is mainly employed as an agent in treating schistosomiasis, which is a disease caused by parasitic worms. It is also useful in the treatment of diarrhoea and general physical malaise[136]. Other authors have reported anthelmintic and antimalarial properties [137], antitumorigenic properties [138], analgesic and antipyretic activities [139], hypoglycemic and hypolipidaemic effect in experimental animals [140]. The reported biologically active phytoconstituents from V. amygdalina are alkaloids, flavonoids, terpenes, saponins, coumarins, xanthones, phenolic acids, lignans, steroids, anthraquinones, edotides [141], and sesquiterpene lactone [142] while Offor[143] determined Zinc and Copper to be 0.812 ± 0.006mg and 0.120 ± 0.006mg respectively.

5.3.6 Cabbages (Brassica spp)

Brassica vegetables are potent modulator of the innate immune response system with potent antiviral, antibacterial and anticancer activity [144]. The extracts exhibit anti-inflammatory, antimycotic, photoprotective, antihyperglycemic,
anticarcinogenic and antioxidant activities. The chloroform extracts retarded microbial growth at the concentration of 33 mg.mL⁻¹ with 13.50 to 14.50, 10.60 to 12.50 and 09.80 to 13.60 mm zone of inhibition against Gram-negative bacteria, Gram-positive bacteria, and fungi respectively. Biochemical analysis indicated that the total phenol and flavonoids contents were 62.6 ± 0.05 mg GAE.g⁻¹ and 27.6 ± 0.04 mg QE.g⁻¹ respectively resulting in enhanced antioxidant activity [145]. Samec et al. [146] confirmed the antioxidant, anti-inflammatory and antibacterial properties of the vegetables.

5.3.7 Carrot (Daucus carota)

*Daucus carota* are important sources of natural antioxidants with anticancer activity. Carrots are also a good source of carbohydrates and minerals like Cu and Zn and vitamins like vitamin C[147]. Due to the appreciable level of a variety of different compounds present, carrots are considered as a functional food with significant health promoting properties [148]. The chemical composition reveals Cu, Zn and vitamin C contents of 0.02 mg/100 g, 0.2 mg/100 g, and 4 mg/100 g respectively amongst others.

5.3.8 Cassava (Manihot esculenta Crantz)

*Manihot esculenta* Crantz ethanol extracts of the leaf had antibacterial activity against *S. epidermidis* and *P. acnes* with the most active fraction indicated by ethyl acetate. The MIC values of ethyl acetate fraction against *S. epidermidis* were in the concentration range of 2.5%–5.0% (w/v) and 1.25%–2.5% (w/v) against *P. acnes*[150]. The MBC value of ethyl acetate fraction against *S. epidermidis* was at a concentration of 5% (w/v), while *P. acnes* was at a concentration of 2.5% (w/v). Cassava roots have calcium, iron, potassium, magnesium, copper, zinc, and manganese contents. The vitamin C (ascorbic acid) content is also high and between 15 to 45 mg/100 g edible portions[151]. The Dimethyl sulfoxide (DMSO) extract developed significant clear zone of inhibition against *Streptococcus pyogenes*, *Staphylococcus aureus*, *Pseudomonasaureginosa*, and *Eschericia coli*.

5.3.9 Celery (Apium graveolus)

*Apium graveolens* L. has antifungal [152] and anti-inflammatory properties [153]. Moreover, its essential oils have antibacterial effects. Celery leaves have the property to remove hydroxy (OH) group and DPPH radicals and the plant also reduces the intensity of liposomal peroxidation [154]. Celery can prevent cardiovascular diseases [155] jaundice, liver and lien diseases as well as gout [156], urinary tract obstruction [157], and rheumatic disorders [158]. Research on rats shows that ethanolic extracts of celery leaves increases spermatogenensis and also improves their fertility [159]. Celery reduces glucose, blood lipids [160] and blood pressure, which can strengthen the heart [161]. Experimental studies show that celery has antifungal [152] and anti-inflammatory properties while Choline ascorbate and phthalides such as butylphthalalidehave been isolated from leaves and roots of A. graveolens, respectively. Apin is found to be the major constituents of the leaves [153].

5.3.10 Garlic (Allium sativum)

*Allium sativum*L has been described as being antimicrobial, antiseptic, antiviral, antioxidant, anticancer, immunostimulatory, cardioprotective, and hypoglycemic [162]. A broad range of pathogenic organisms, including bacteria, fungi, protozoa and viruses have been shown to be sensitive to fresh crushed garlic [163]. The beneficial effects associated garlic may be due in part to sulfur-containing compounds such as allicine, diallyl disulfide, diallyl trisulfide that react with thiol groups of various enzymes which are critical for microorganism surveillance [164]. Spyridon et al. [165] reviewed the Pharmacological effects of Allium hirtifolium and found Zinc of considerable amounts while Reynhan [166] determined the chemical composition and reported a vitamin C content of 31mg. Deepak et al.[167] indicated that garlic extracts singly had a greater potency than 1% chloramphenicol producing significant susceptibility manifested by inhibition zone of 51 ± 0.19 mm towards *B. cereus* and 37 ± 0.17mm on *S. aureus E. coli* (34 ± 0.48).

5.3.11 Ginger (Zingiber officinale)

Zingiber officinale rhizome can be employed in the form of fresh paste, ginger tea (flavoring), dried powder and preserved slices [168]. Ginger can be available in different commercial products like cookies, candy, teas, tinctures, sodas, jam, beer, capsule and syrup [169]. The chief active constituents of ginger are Volatile oil (zingiberene, zingiberol, D-camphor), Shogaols, Diarylheptanoids, Gingerols, Paradol, Zerumbone, 1-Dehydro-(10) gingerdi-one,
Terpenoids and Ginger flavonoids [170]. Shogaols and Gingerols are responsible for ginger’s pungency [171]. Ginger has wide range of biological activities that are attributed to its active constituents [172]; Anti-viral effect [173], Anti-inflammatory effect [174], Anticancer activities (e.g. breast cancer) [175], Neuroprotector effect [176], anti-ulcerative effects [177]. Ginger is claimed to cure a variety of diseases such as nausea, vomiting, asthma, palpitation, inflammation, dyspepsia, loss of appetite, constipation, digestion and pain [177,178].

5.3.12 Guava (Psidium guajava)

Psidium guajava methanolic and ethanolic extracts have been reported to demonstrate antibacterial activity on gram positive bacteria with mean zones of inhibition of 8.27 and 12.3 mm, and the ethanol extract had a mean zone of inhibition of 6.11 and 11.0 mm against B. cereus and S. aureus, respectively [179]. Goncalves et al [180] indicated that the inhibition halos seen surrounding discs soaked in the extracts of methanol, hexane, ethyl acetate essential oils from guava leaves varied from 7.00 mm to 11.25 mm with Staphylococcus aureus, Salmonella spp. and Escherichia coli being sensitive to at least one of the extracts while Nwinyi et al. [181] evaluated the MIC of the aqueous extract of Psidium guajava to be 5.0 and 2.5 mg ml$^{-1}$ for E. coli and S. aureus respectively whereas that of the ethanol extract was 1.25 mg ml$^{-1}$ and 0.625 mg ml$^{-1}$ for E. coli and S. aureus respectively.

5.3.13 Honey

Though the bacteria concentration used was higher that recommended by the Clinical and Laboratory Standards Institute (CLSI) guidelines (105–106 cfu/mL), For the activity of 100% pure honey, the largest zones observed were against Escherichia coli (1.4 × 109 cfu/mL) M 35 ± 0 mm, CS 36 ± 1.0 mm and CW 36.6 ± 0.6 mm. The zones of inhibition values for Pseudomonas aeruginosa (1.4 × 109 cfu/mL) were M 26.3 ± 0.6 mm, CS 34 ± 2.0 mm and CW 33.7 ± 3.2 mm whilst the zones of inhibition against Staphylococcus aureus (1.9 × 108 cfu/mL) were M 18.7 ± 1.2 mm, CS 16.6 ± 0.6 mm and CW 17.0 ± 0.0 mm [182].

5.3.14 Huckleberry (Solanum nigrum)

Solanum nigrum is an anti-tumor gene agent, antioxidant, anti-inflammatory, hepatoprotective, diuretic and antipyretic [183]. It is reported to inhibit growth of cervical carcinoma via modulation of immune response of tumor bearing mice and inducing apoptosis of tumor cells [184]. It has proven also to be a reservoir of phytochemicals with pharmacological prospects. Leaves and berries of Solanum nigrum are commonly used in South India for the treatment of gastric ulcers, gastritis and other gastric problems [185]. Depending on the extraction solvent, Solanum nigrum demonstrated pharmacological activities. The Hepatoprotective activity came from the aqueous and methanolic extracts [186]. Hapeep et al. [187] reported antimicrobial activity from the methanolic and aqueous extracts, anti-gastritis and antiulcerogenic effects in the aqueous extract while the methanolic extract produced cardioprotective activity. The ethanolic extract also produced analgesic activity [188] and antidiarrhoeal activity [189].

5.3.15 Lemon (Citrus limon)

Citrus limon (L.) Burm. F. fruit and vegetable are used to wash for oral health to freshen your breath and to treat flaky dandruff, headaches and reduce asthma symptoms [190] while the anticancer and antibacterial properties of crude extracts of the different parts have against clinically significant bacterial strain has been reported [191]. Mineral composition in mg/100g is 13.94±0.007 for Zinc and 4.94±0.012 for Copper [192]. The volatile components of the essential oils contain a mixture of monoterpene, sesquiterpene and their oxygenated derivatives and the non-volatile compounds include hydrocarbons, flavonoids, sterols, fatty acids, coumarins, waxes, carotenoids and psoralens [193] which is responsible for the antibacterial activity observed against B. cereus with a zone of inhibition of 33.46 mm followed by S. aureus, S. faecium, E. coli, and S. dysentery with inhibition zones of 31.52 mm, 30.21 mm, 29.33 mm, and 18.19 mm, respectively at 10 mg/mL concentration [194].

5.3.16 Lemongrass (Cymbopogon)

Cymbopogon citratus Stapf extracts contained several medicinal chemical components which reside in its essential oil and aqueous extract [195]. Tea made from the leaves is popular among countries of South America, Asia and West Africa having been widely utilized as antiseptic, antifever, antidyseptic, carminative and anti-inflammatory effects while others use is
as febrifuge, analgesic, spasmylytic, antipyretic, diuretic, tranquilizer and stomachic agents [196, 197].

5.3.17 Lime

*Citrus aurantiifolia* L. health benefits include weight loss, skin care, good digestion, relief from constipation, eye care, and treatment of scurvy, piles, peptic ulcer, respiratory disorders, gout, gums, urinary disorders, etc. It is used in curing giddiness, vomiting, nausea, thirst, scurry and in febrile and inflammatory conditions[198]. The mineral composition of lime indicated that zinc and copper contents were 0.4 and 5.56 and mg/100gm) respectively[199].Aronson, [200] reported ascorbic acid contents of 22.86 ± 0.426 were in accordance with the Brazilian Identity and Quality Standard of 2000 that determines a minimum of 20.0 mg.100 g for ascorbic acid in acid lime juice [201].

5.3.18 Mangoes (*Mangifera indica*)

*Mangifera indica*. Mangoes contain several important phytochemicals including cryptoxanthin, lutein, galic acid and anacardic acid. It contains, B-carotene which may slow the aging process, reduce the risk of certain forms of cancers, improve lung function, and reduce complications associated with diabetes. It is rich in antioxidants such as beta carotene (44.5g/100g fruit) and vitamin C (27.79’/100g fruit)[202]. However, great variations exist in the vitamin C content, fluctuating from 9.79 to 186 mg/100 g of mango pulp [203, 204]. Mangoes also supplies zinc (0.04mg/100g) and copper (Copper mg 0.110 mg/100g) amongst other nutrients.

5.3.19 Masepo (*Occimum gratissimum*)

*O. gratissimum* Lis an aromatic medicinal and important herbal medicinal plant. The leaves are rubbed between the palms and sniffed as a treatment for blocked nostrils. People use Masepo for various purposes like viz., the leaves are rubbed between the palms and sniffed as a treatment for blocked nostrils, they are also used for abdominal pains, sore eyes, ear infections, coughs, barrenness, fever, convulsions, and tooth gargle, regulation of menstruation and as a cure for prolapse of the rectum [205]. Evaluation of the antimicrobial activity against pathogenic strains of Gram positive (*S. aureus, Bacillus spp.*) and Gram negative (*E. coli, P. aeruginosae, S. typhi, K. pneumoniae, P. mirabilis*) bacteria and a pathogenic fungus *C. albicans* indicated that the essential oils were active active against all the bacterial strains [206]. Whole plant is used for the treatment of sunstroke, headache, influenza, as a diaphoretic, antipyretic and for its anti-inflammatory activity [207].

5.3.20 Mondia spp

Traditionally, *Mondia whitei* is a valuable plant in the management of diseases [208]. It is effective in the treatment of malaria, premature ejaculation, and low sperm production, loss of appetite, gonorrhoea, paediatric asthma, and gastrointestinal disorder. It is effective in the treatment of malaria, premature ejaculation, and low sperm production, loss of appetite, gonorrhoea, paediatric asthma, and gastrointestinal disorder [209]. One teaspoonful of the root extract 3 times daily is used for de-worming children [210]. The antimicrobial effect of *M. whitei* root has been reported by previous authors[211]. Also, Mayunzu et al. [212] reported the antioxidant activity of various concentrations of the root extract. The mineral composition analysis reveals copper and Selenium contents of 1.47±0.05mg/100g and 0.0108±0.0040 mg/100g respectively[213] as well as Zinc of 0.03 0.07 mg/100g [214].

5.3.21 Mushroom

Mushrooms are used in the treatment and prevention of diseases and they exhibit varied biological properties such as antibacterial, antimitagenic, antitumoral and antiviral activities [215]. The most widely distributed molecules with antitumor properties in mushrooms are sesquiterpenes, triterpenoids, glucans and glycoproteins [216]. Traditionally, people consume mushrooms also for medicinal reasons such as reducing obesity (Armao et al., 2001)[217]. They are used in the treatment and prevention of diseases and they exhibit varied biological properties such as antibacterial, antimitagenic, antitumoral and antiviral activities. The most widely distributed molecules with antitumor properties in mushrooms are sesquiterpenes, triterpenoids, glucans and glycoproteins [218]. The range of reported literature values (mg/100 g dry weight basis) for Zinc, Copper and Selenium in mushroom is 2.98–15.8, 7.1–9.5, and Selenium 1–5[219] for different wild species.

5.3.22 Okro (*Abelmoschus esculentus*)

*Abelmoschus esculentus* is commonly known as ladyfinger, gumbo, ockro, okro and bhindi [220].
It has health benefits in genitourinary disorder, controls, cholesterol, cold and cough, chronic dysentery, hypertension, spermatorrhoea, ulcer, relieves hemorrhoids and possesses anti-inflammatory properties [221]. Okro has shown a broad range of inhibitory properties against bacterial isolates (L. monocytogenes, B. cereus, S. aureus, E. coli and Salmonella enterica) at 100mg/ml [220]. The vitamin C content evaluated was 13mg [222]. The phytochemicals compounds present in Okra confer it with antioxidant, anti-ulcer, anticancer, antimicrobial, hypoglycaemic, hypolipidemic and anti-diabetic properties [223]. The DPPH radical scavenging activity of okro ranged from 79.81 to 99.26%. The ferric ion reduction capacity observed with the variety V55 was 57.91 mmol EAA / g [224].

5.3.23 Onion (Allium cepa)

Allium cepa L. onions have 25 active components, like the sulphur which is the worthiest substance found in onion, it acts as an anti-inflammatory, thiosulfimates also can act as anti-thrombotic and superoxide-dismutase (SOD) which act as an anti-oxidants [225]. Onions contain high levels of phenolic compounds, which have antioxidant properties besides beneficial effects against different degenerative pathologies (cardiovascular and neurological diseases, dysfunctions based on oxidative stress) [226]. The cell wall of the onion is rich with Uronic acid, glucose and smaller amount of arabinose, xylose, fructose and galactose which are found in the lower epidermis of the onion scale [225].

5.3.24 Pawpaw (Carica papaya)

Carica papaya fruit is rich in provitamin A, carotenoids, lycopene, vitamins, dietary minerals and dietary fibre. The skin, pulp and seed contain varieties of phytochemicals including natural phenol and flavonoids which have antioxidant properties. The pulp and seed contain varieties of phytochemicals including natural phenol and flavonoids which have antioxidant properties and have also demonstrated anthelmintic and antiamoebic in activities as well as anticancer and anti-diabetic properties [227]. The zinc content of Pawpaw has been reported to be 68.00/100g [228].

5.3.25 Palm Wine

Palm wine has been used locally as an extractant to extract active ingredients from leaves, barks and stems of some medicinal trees used in the treatment of various ailments which include malaria, dental problems, yellow fever, pains and stomach disorders. It is also used locally in the treatment of skin rashes in children [229]. Generally, the fermented and unfermented palm wine has several nutritional, medical, religious and social uses which have been reported elsewhere [230], to have increasingly enhanced the demand for this natural product. Palm wine is consumed for its nutritional effect because of its probiotic content [231, 232]. Palm sap contains nutritionally important components including amino acids, Proteins, vitamins, Sugars and micronutrients. The antibacterial activity of Palm wine studied against the pathogens like Pseudomonas species and Klebsiella species by agar well diffusion method showed antibacterial activity against Klebsiella species (23mm inhibition zone diameter) and Pseudomonas species (20mm inhibition zone diameter) [233].

5.3.26 Pepper (Capsicum annuum)

Capsicum annuum have demonstrated antimicrobial activity illustrated by growth inhibition of gram positive and gram negative bacteria such as Staphylococcus sp., and Escherichia coli, respectively. Traditionally, Capsicum has been employed for the treatment of Candida albicans [234]. The phytochemical analysis revealed that the methanolic extract is richer in polyphenols than flavonoids and the extract had antiradical scavenging property at 64.1 μg/ ml for 50% DPPH radical and for MTT assay. However, the cytotoxicity of the extract was relatively low, for example IC_{50}= 1078.69μg/ml) against Vero cells. The extract at a concentration of 25 μg/ml also exhibited a considerable anti-HSV-1 and anti-HSV-2 activities [235]. The methanolic and aqueous extracts were effective against Vibrio cholerae, Staphylococcus aureus, and Salmonella typhimurium, but the extracts of methanol had the greatest effect. Capsicum annuum extract demonstrated higher antibacterial activity than those from Capsicum frutescens with a MIC of the methanol and aqueous extracts of 0.20 mg ml^{-1} and 0.25 mg ml^{-1} respectively. Minimal bactericidal concentrations values of both extracts ranged from 1 to 2.5 mg ml^{-1} [236].

5.3.27 Pineapple (Ananas comosus)

The extracts of the various parts of A. comosus revealed antibacterial, antiviral, antifungal, antiparasitic and anti-inflammatory properties...
The root and fruit are either eaten or applied topically as an anti-inflammatory and as a proteolytic agent. In the Philippines, pineapple is traditionally used as an anthelmintic agent with the root decoction effective against diarrhea [238]. The anti-inflammatory properties in the fruit help reduce the symptoms of arthritis, and help ease pain after surgery and sport injuries. The bromelain in pineapple is known to help relieve or even stop coughs altogether as well as loosening of mucus. Bromelain has shown to exhibit various fibrinolytic, antiedematous, antithrombotic, and anti-inflammatory activities both in vitro and in vivo[239]. The chemical composition for 100g of sample gave 0.08 mg of Zinc, 0.110 mg of Copper and 15.4mg of Vitamin C [202].

5.3.28 Plantains (Musa paradisiaca)

Musa paradisiacais is used as a medicinal plant employed in traditional system of healing diverse diseases such as hepatitis, skin infections, problems concerning the digestive organs, respiratory organs, reproduction, the circulation, anti-inflammatory, antiviral, analgesic, antioxidant, anti-carcinogenic, antitumor, antinociceptive (reducing the sensitivity to painful stimuli), weakly antibiotic, immune modulation, antiulcerogenic, anti-leukemic and antihypertensive effects, and for reducing fever [240]. The mineral composition of plantain during the ripening process revealed zinc content of 7.92±0.02mg for the unripe, 9.52±0.40mg for semiripe and 11.43±0.05mg for the ripe [241].

5.3.29 Plums (Prunus domestica)

Prunus domestica is considered as a respectable source of nutrients due to the content of ascorbic acid, monosaccharides, various minerals, dietary fiber, and phenolics, such as chlorogenic, benzoic, vanillic, and caffeic acid [242]. The fruit of P. domestica is a potent antibacterial activity [243]. Plums contain copious amount of natural phenol phytochemicals, such as flavonoids and phenolic acids, which may function as natural antioxidants in our daily diet [244]. Phenolic compound in the plum have been found to play an important role in preventing cell membrane from oxidative damages induced by active oxygen radicals in living systems as dietary antioxidants and anticarcinogenic, antioxidantic, antimutagenic, and anti-inflammatory activities as well [245]. The prune DMSO extract presents an important protective activity against erythrocytes hemolysis (31.35 ± 0.28 %) at a concentration of 400 μg/ml suggesting the potential of the extracts as a new source of natural neuro-protective agent. Antibacterial tests showed a remarkable power, especially, against Staphylococcus aureus and Escherichia coli for the two extracts studied [246].

5.3.30 Pumkin (Cucurbita spp)

Cucurbita leaves, fruits, flowers and seeds are health promoting foods. The leaves are haematic, analgesic, and also used externally for treating burns. Traditionally, the pulp used to relieve intestinal inflammation or enteritis, dyspepsia and stomach disorder [247]. Pumkin is also rich in vitamin C and lycopene [248]. Pumpkin seed are known as nutritional powerhouse, as these seeds are excellent nutrient source filled with minerals mainly zinc, phosphorous, magnesium, potassium and selenium responsible for fighting diseases and acts as weapon for fighting diseases such as arthritis, inflammation, prostate cancer etc [249]. Pumkin seed oils displayed activity profile with considerable antibacterial activity against Klebsiella pneumoniae and Acinetobacter baumannii (16 μg/mL), potent antifungal activity against Candida albicans (8 μg/mL), as well as a moderate antiviral effect towards Parainfluenza virus type-3 (16-8 μg/mL) [250].

5.3.31 Yam (Dioscorea spp)

Yam has been used as a folk remedy to treat conjunctivitis, diarrhea, and dysentery, among other ailments. D. bulbifera has been traditionally used to lower glycemic index, thus providing a more sustained form of energy and better protection against diabetes and obesity. It also possesses anticancer properties with extracts reported to be antihyperlipidemic, antitumor, antioxidant, anorexiant, analgesic and anti-inflammatory, and antihyperglycemic. The aqueous and chloroform extracts were found to exert significant inhibitory activities against Escherichia coli, Acinetobacter sp., Salmonella paratyphi, Klebsiella pneumoniae, and Candida albicans with the greatest inhibitory activity exerted on K. pneumoniae presenting a wide inhibition zone diameters (17 ± 0.15 mm), followed by E. coli (13 ± 0.11) mm, and Acinetobacter sp. (11 ± 0.12)[251]. At 0.5 mg/ml acetone and methanol extracts exhibited activity against against S. pyogenes [252].

[237] [238] [239] [240] [241] [242] [243] [244] [245] [246] [247] [248] [249] [250] [251] [252]
5.3.32 Tomatoes

Tomato fruit contains phytochemicals that showed promising antimicrobial effect on oral thrush and cariogenic pathogens. The tomato extract recorded antimicrobial effect against Bacillus subtilis with MIC of 100 mg/ml[253]. Some studies have shown that tomatoes have cancer prevention effect which is that lycopene and the newly discovered bioflavonoids in tomatoes are responsible cancer fighting agents [254]. The total antioxidant activity of tomato fruits is commonly classified into hydrophilic and lipophilic ones. The first is conferred mainly by soluble phenolic compounds and vitamin C and shows a significant impact on total antioxidant activity (83%), while the latter is conferred by carotenoids, vitamin E, and lipophilic phenols (17%) [255]. The minimal inhibitory concentration (MIC) of the extracted tomato glycosides against Escherichia coli was determined to be 3.54 mg/mL through agar diffusion test. The effects of pH, temperature and reaction time on the anti-bacterial activity of the tomato glycosides were investigated. The bacteriostatic effect of the tomato glycosides was stronger than that of 1.5% sodium benzoate. The tomato glycosides exhibited the strongest anti-bacterial effect at pH 7[256] and have a Zinc content of 0.11–0.26 mg/100g [257].

5.3.33 Sweet Potato

Several reports have indicated that the phytochemicals in sweet potato possess multifaceted actions, including anti-oxidant, antimutagenic, anti-inflammatory, antimicrobial and anti-carcinogenesis and thus are important for several health-promoting functions in humans [258]. The analysis of zinc content of the samples showed that cultivars E5 (cream flesh), E6 (white flesh), E4, E10 (Yellow fleshed) and E8 (orange flesh) presented the same zinc content (0.27 mg/100g) which is the highest value among all the ten cultivars [259].

6. CONCLUSION

The objective of this paper was to provide a non-exhaustive list of common foods and herbs rich in Zinc, Copper and Selenium principle as well as foods with demonstrated antioxidant and antimicrobial properties to emphasize on the regular consumption as a means to strengthen the immune system and tonifying the body energy to prepare for and fight against viral invasion. Limited resourced or low income countries in sub-Saharan African like Cameroon with limited access to fundings, technology, experts and materials can only rely on natural sources like common foods while waiting for a convincing, effective and efficient drug and/or vaccine for the novel covid-19 disease. In addition research have elucidated the viral chelating activities of Zinc, Copper and Selenium which on the one hand are essential micronutrients which are responsible for various homeostatic activities in the human body and on the other other hand which can cheaply be obtained from selected common food. Furthermore, foods with demonstrated antioxidant and antimicrobial can be used to attenuate the increase in microbial action and reactive oxygen stress after viral infection. A non-exhaustive list of such foods have therefore been present by this study for the attention of the population to emphasize on their consumption so as to meet the ADIs and RDAs of the micronutrients on the one hand and supply the body with enough natural antioxidants and antimicrobials.

DISCLAIMER

The products used for this research are commonly and predominantly used products in our area of research and country. There is absolutely no conflict of interest between the authors and producers of the products because we do not intend to use these products as an avenue for any litigation but for the advancement of knowledge. Also, the research was not funded by any producing company rather it was funded by personal efforts of the authors.

CONSENT

It is not applicable.

ETHICAL APPROVAL

It is not applicable.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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