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ARTICLE

Rediscovering Pride in Agricultural Heritage through Cultivation of African Indigenous Vegetables (AIVs) as Climate Acquiescent Vegetables, Immune and Health in Response to COVID-19 Pandemic in Zimbabwe

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ABSTRACT

African Indigenous Vegetables are asserted to cope with climate variability besides their great potential as both food and medicine in Zimbabwe. They can be easily grown in drought prone areas with low rainfall as they are resistant to adverse environmental factors. Inimitable opportunities are offered through cultivation of AIVs to diversify farming systems so as to ensure food security and are cheap alternatives as compared to their expensive exotic counterparts. Alternative approaches to reduce escalating numbers of current Covid-19 patients and death is to introduce nutrient intervention through rediscovering of pride in agriculture through cultivation and commercialisation of AIVs in Zimbabwe. AIVs have great potential to improve immune response by supplementing dietary requirements (micronutrients) of an individual and can have a positive impact on COVID-19 outcome as they play a significant role in the immune system. AIVs have antifungal, acaricidal, antiviral, anticancer and act as immune stimulants. There is need for persuasive research based information, suitable national legislation and information campaigns on cultivation and consumption of AIVs in Zimbabwe.

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1. Introduction

Current evidence shows that climate change is affecting crop productivity with direct impacts on the nearly 70% of people in agro-based rural areas of developing countries [121,122]. Indigenous traditional vegetables are plants that are endemic or introduced whose leaves, flowers and/fruits have been utilised for decades and many generations thereby becoming part of the culture and tradition of communities [85,76]. African Indigenous vegetables (AIVs) production has gained traction as a viable adaptation option in Zimbabwe especially in dryland regions. AIVs production has a potential to build capacity and enable rural communities to be resilient against the quirks of climate change impacts. In Zimbabwe, indigenous communities have relied on AIVs for food security, medicinal, social, cultural and income generation [85].

AIVs are asserted to cope with climate variability beside their great potential as both food and medicine. Most of the AIVs grow naturally in certain areas and generally they are adapted to harsh environments [76]. They can be easily grown in drought prone areas with low rainfall as they are resistant to adverse environmental factors [98]. [111] highlighted that the most consumed AIVs include vegetable amaranth (*Amaranth species*), spider plant (*Cleome gynandra*), African kale (*Brassica carinata*), jute mallow (*Corchoru solitorius*), African nightshades (*Solanum species*), cowpeas (*Vigna unguiculata*) and African eggplant (*Solanum aethiopicum*).Notably, AIVs are generally compatible with starchy staples and therefore striking a balanced between cost and quality nutrition for the poor in both urban and rural areas [112,85,75].

AIVS provide nutrients such as vitamin A, C, iron and proteins which are essential for human growth and development [6,123,55]. [45] postulated that African indigenous vegetables play a significant role in reducing malnutrition, increasing incomes, and maintaining biodiversity. [4]AIVs have been neglected by researchers, policy makers and funding agencies and have yet to be fully integrated into the mainstream of agricultural production. Although production of these vegetables is generally on a small-scale where traditional knowledge is employed [100], marketing of AIVs is becoming an important driver of income generation in SADC Region, [71]. Research is therefore needed on cost effective ways to increase the consumption of indigenous vegetables by promoting their nutritional, medicinal, cultural and culinary properties.

Of particular concern is underutilisation of AIVs, which is linked with loss of indigenous knowledge, food and genetic diversity [99]. In commercial farming systems, AIVs are considered as weeds and therefore they continually destroyed and this is contrary to the issue of food shortages, malnutrition and high unemployment in rural communities [86]. Concisely AIVs are critical in diversification of farming systems, which enhances food security at household level [86,76]. AIVs contribute positively to the level immunity in an individual and offer cheaper alternatives to the more expensive commercially produced vegetables due their nutritious nature [53].

The uniqueness of AIVs lies in their ability to grow quickly and mature early thereby becoming an integral part of sustainable nutrition-intervention programmes [75]. Several authors have indicated that interventions designed to increase vegetable consumption among adults and children can be effective [64,92,108]. It needs therefore, to unravel the potential opportunities of AIVs as immune stimulation and perceived constraints faced by poor smallholder farmers in cultivating indigenous vegetables so as to be able to devise adoption and dissemination strategies to best meet their needs. Limited demand and discrimination have been major constraints to the production of AIVs in Zimbabwe. Lack of research on AIVs has led to the loss of indigenous knowledge systems and thus this review seeks to document cultivation of (AIVs) as climate acquiescent vegetables, immune and health in response to Covid-19 pandemic in Zimbabwe.

Exotic crops such as rape, cabbages, tomatoes and onions are conversantly taught in Zimbabwean Agricultural classes. AIVs are mentioned as wearisome weeds. The review paper seeks to revive pride in agricultural heritage through cultivation of African Indigenous vegetables (AIVs) as climate acquiescent vegetables in Zimbabwe in response to Covid-19 pandemic awareness.

2. AIVs as Immune Promoters in Response to Covid-19 Pandemic

According to [10], coronavirus disease-19 (COVID-19) is a highly contagious disease that was identified in China in December 2019 and is caused by severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) a single-stranded RNA virus.

The Huanan Seafood Market in Wuhan, China, was implicated as the origin of the novel coronavirus (SARS-CoV-2) [69]. Coronaviruses are diverse RNA viruses that exist in two important hosts: mammals and birds. These viruses mainly cause respiratory and, less often, gastrointestinal diseases [25]. The major respiratory symptoms caused by coronaviruses normally range from mild influenza like symptoms which usually appear 5–6 days after infection to severe pneumonia [39]. The other symptoms linked to COVID-19 include sore throat, fever, muscle

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and body aches and loss of smell or taste in some cases [124]. According to the RNA sequencing SARS-CoV-2 and bat coronavirus possess a similarity of gene sequence up to 96.2%, and this suggests bats as the possible source of SARS-CoV2 [39].

The role of the immune system is to protect the host from invading agents particularly pathogens such as bacteria, viruses, fungi and worms [21]. The protective effect of the human immune system lies in the existence of body barriers and immune system cells. Immune responses after infection are coupled with increased metabolic rate, where metabolism is an active process that allows biosynthesis of critical substrates and regulatory molecules [43]. The energy utilised in biosynthesis is derived from the diet and therefore AIVs provide some of nutrients for optimum functioning of the immune system [20]. Disturbingly, SARS-CoV-2 is novel to the human immune system and therefore lack of primary natural immunity against the virus [21].

Nutrients play a central in supporting the immune system, providing antiviral defences, overcoming gut microbial dysbiosis and in calming cytokine storm [21, 39]. Individuals with underlying conditions such as diabetes, cardiovascular disease, respiratory disease and suppressed immune systems are particularly susceptible to severe symptoms and mortality [13]. Although the search for vaccines that offer immune protection against SARS-CoV-2 has yield positive results, most countries including Zimbabwe are still to get hold of these vaccines [66]. In the meantime, it is critical for individuals' immune systems to be strengthened. Among other strategies, nutritional intervention is central in boosting the immune system. In addition to this, there is a high chance of antimicrobial resistant infections emerging in a number of societies, and in such instances, nutritional status is imperative in the maintenance of a strong immune system against the virus [11].

AIVs are excellent sources of vitamins A and C, and iron, protein, minerals and fibre [102]. [110] declared that these micronutrients are an essential component for people without access to meat or other sources of protein. Micronutrients forms an essential component of dietary requirements of an individual and have a positive impact on COVID-19 outcome as they play a significant role in the immune system [24]. Generally, immune cells require enough energy, macronutrients and micronutrients to maintain an effective immune response [22]. Besides providing micronutrients and macronutrients, AIVs are sources secondary metabolites with antioxidant potential. Methanol extraction of spider plant (*Cleome gynandra*) produced total antioxidant potentials [88]. These anti-oxidants have the ability to bind harmful free radicals in the body which cause diseases such as cancer and diabetes[81]. Studies by [90] postulated that vegetable antioxidants enhance natural kill cells ad lymphocytic activity and increase interleukin-2-production.

3. Micronutrients and the Immune System

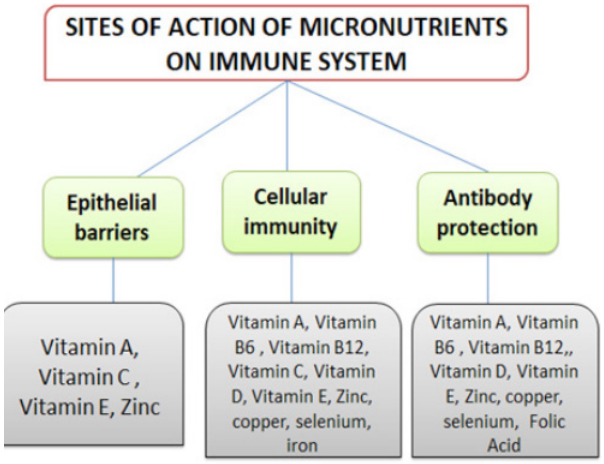

Figure 1. Sites of action of micronutrients: Adapted from [82]

[1] highlighted that drug shortages have been reported hence natural sources to supplement these elements are required to boost the immune system. Drugs and vaccines are under trial whilst the number of people succumbing to Covid-19 is on the rise in Zimbabwe. Alternative approaches to reduce escalating numbers is to introduce nutrient intervention like the commercialisation of AIVS in Zimbabwe so as to improve immune response against this disease. AIVs becomes a recommendation for the dietary supplementation of essential micronutrients. [56,21] proposed the use of nutrients to protect against many infectious diseases and reduce lung damage in pulmonary infections.

4. African Indigenous Vegetables (AIVs) as Climate Acquiescent Vegetables

With the changing climate and marginal soils common among the resource poor farmers, AIVs can produce better yields in marginal and poor conditions with fewer inputs and less labour than other staples [19]. AIVs show substantial biodiversity and can be grown with minimal external inputs [29,50]. With their ability to grow in diverse environments with minimum resources, traditional vegetables can support conventional agricultural practices, and provide insurance against drought and crop failure [85]. AIVs ensures food security and highly nutritive food while backing to the resilience of the community to changes in

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Table 1. Some of the nutrients and minerals from AIVs and their significance on the immune system and combating COVID-19

Nutrient/mineral	Role in immune system	Other roles in reducing effects of COVID-19	Source (s)
Vitamin C	• Vital in collagen biosynthesis and maintenance of epithelial integrity. • Important in leucocyte migration to sites of infection, phagocytosis and bacterial killing • It is critical in natural killer cell activity, T lymphocyte function (especially of CD8+ cytotoxic T lymphocytes) and antibody production.	• Decreases the duration and severity of upper respiratory tract infections, • Reduces exposure of the respiratory system to serious infections including pneumonia.	[11] [30] [82] [13] [21] [47] [23]
B-group Vitamin	• Important in intestinal immune regulation, and contributes to gut barrier function. • Maintain and support the activity of natural killer cells and CD8+ T lymphocytes, and this plays an important role in antiviral defence. • Generally, vitamin B6 increase the percentage and total number of circulating lymphocytes, • It improves T and B lymphocyte proliferation and IL-2 production.		[131] [21] [82]
Vitamin A	• Immune cell maturation and function • Innate immunity modulation • Controls neutrophil, dendritic cell and CD4+ T lymphocyte maturation • Maintains balance between T helper 1 and T helper 2 lymphocytes • Supports phagocytic activity and oxidative burst of macrophages, • When vitamin A is metabolised produces 9-cis retinoic acid and this metabolite promotes T helper 1 responses. Moreover, retinoic acid is critical in the movement of T lymphocytes to the gut lymphatic system and in CD8+ T lymphocyte survival and multiplication. Retinoic acid is important in the normal functioning of B lymphocytes and in antibody synthesis	• Allows normal differentiation of epithelial tissue • Reduce entry pathogens modulation of body barriers	Brown and Noell, [18] [68] [34] [101] [82]
Iron	• Prevents thymus atrophy, thereby increase production of naive T lymphocytes • Improves bacterial killing, natural killer cell activity, T lymphocyte proliferation and production of T helper 1 cytokines.	• It promotes impairment of respiratory burst • Although complex, presence of iron reduces susceptibility to infections	[91] [26] [40] [125]
Zinc	• Inlvolved in DNA synthesis and cell proliferation thereby important in the production of immune cells • It is critical in the regulation of innate and adaptive immune responses, and cell signalling. • Is an inhibitor of RNA polymerase, which is central in multiplication RNA viruses like coronaviruses.	• Lowers susceptibility to diarrhoeal, respiratory and skin infections. • Reduces chances of recurrent respiratory tract infection in children and shorten the duration of common cold in adults.	[48] [109] [80] [82]
Magnesium	• Is an electrolyte that aids strengthening of the immune system's natural killer cells and lymphocytes. • It is a source of energy (adenosine triphosphate (ATP)) for cellular biosynthesis and other energy requiring process.		[11] [13]

climatic conditions because they are well adapted to the ecological conditions of the area [19]. Disease suppression and buffering against climate variability is of great relevance to smallholder farmers with limited resources [70].

4.1 Food Security and Nutritional Security

Generally, AIVs have a great potential in addressing poverty and nutritional security issues considering affordability and accessibility [95]. More importantly, AIVs easily grow, require minimum production inputs, have high vitamin and mineral content, and are rich important immune boosting secondary metabolites [85]. Until this day, food security continues to be a serious problem in several rural communities in Zimbabwe [76]. Traditional vegetables previously preserved by drying become very important in household food security during the period of relish shortage, especially in the dry season (the relish-gap period[86]. [77] pointed out that access to sufficient nutritious food which meet dietary requirements to be healthy and active is termed food security. Moreover, food security can be defined as access by all people at all times to enough food for an active and healthy life [76]. AIVs grow quickly and

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Table 2. Selected indigenous vegetables consumed in some parts of Zimbabwe

Scientific name	Common name	Local shona/ Ndebele name	Utilization
Amaranthus hybridus Amaranthaceae	Pigweed	Bonongwe, mowa	Young, tender leaves are cooked fresh or after drying
Adansonia digitata Bombacaceae		Derere-muuyu	Young, tender leaves are cooked fresh or after drying
Ceratotheca sesamoides Tiliaceae		Bupwe	Young, tender leaves are cooked fresh or after drying
Scenicio erubescence Astereceae		Chirevereve/ Chiribwiribwi	Young, tender leaves are cooked fresh or after drying
Abelmoschus esculentus	Okra	Derere chipodzi	Fruit
Corchorus olitorius Tiliaceae	Jute mallow	Derere gusha	Young, tender leaves are cooked fresh or after drying
Corchorus tridens Tiliaceae	Jute	Derere munda	Young, tender leaves are cooked fresh or after drying
Adansonia digitata Bombacaceae		Derere-muuyu	Young, tender leaves are cooked fresh or after drying
Cleome monophylla Capparaceae	Spindle weed	Mujakari, musemwasemwa	Young, tender leaves are cooked fresh or after drying
Cleome gynandra Capparaceae	Spider , Cat whiskers	Nyeve, rhude/ ulude	Young, tender leaves are cooked fresh or after drying
Bidens pilosa Asteraceae	Black jack	Tsine, mhuuyu	Young, tender leaves are cooked fresh or after drying
Galinsoga parviflora	Gallant soldier	Teketera	Young, tender leaves are cooked fresh or after drying
Legenaria siceraria	Gourds		Fruit
Vigna unguiculata	Cow peas	Munyemba	Young, tender leaves are cooked fresh or after drying
Cucumis anguria		Cucumber	Young, tender leaves are cooked fresh or after drying ad fruit consumed raw
Cucurbita maxima	pumpkins	Boora	Matured fruit cooked and leaves are cooked fresh or dried
Curcubita pepo	pumpkins	Boora	Fruit and leaves are cooked
Solanum nigrum	Nightshade		Young, tender leaves are cooked fresh or after drying

Modified table: source [87, 86, 95]

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Table 3. Nutrient content of the analyzed selected wild vegetables per 100 g dried portion

Nutrient	*Cleome gynandra*		*Amaranthus hybridus*		*Bidens pilosa*		*Corchorus tridens*	*Adansonia digitata*
	uncooked	cooked	Uncooked	Cooked	Uncooked	cooked	Uncooked	uncooked
Crude protein (g)	5.82±1.0	4.70±0.50	4.94±0.46	4.66±0.33	4.4±0.78	3.7±0.30	5.10±0.54	4.23±0.68
Crude fiber (g)	1.57±0.39	1.7±0.49	1.5±0.08	1.7±0.19	1.7±0.45	2.1±0.09	4.2±0. 78	3±0.48
Carbohydrate (g)	8.94±0.17	7.58±1.9	8.7±0.9	6.9±0.68	8.84±1.39	6.40±0.77	14.0±1.78	18±2.10
Fat (g)	0.4±0.091	1.3±0.23	0.4±0.27	1.0±0.46	0.5±0.50	0.6±0.37	0.3±0.12	0.4±0.29
Potassium (mg)	129±58	131±69	550±98	530± 7	600±53	580±95	370±93	1090±109
Calcium (mg)	120±58	115±99	798±112	530±88	370±67	300±79	380±97	400±120
Magnesium (mg)	97±17	70±23	440±111	343±118	600±126	570±119	290±96	370±99
Phosphorus (mg)	14±4.0	10±5	550±117	450±134	500±109	480±115	623±123	66±11
Iron (mg)	13.12±2.46	9.5±1.09	11.4±0.77	7.3±0.99	17.47±3.4	15±2.7	8.67±1.77	23±3.68
Zinc (mg)	10.36±2.43	1.73±0.55	5.8±1.09	4.90±0.73	22±2.65	19.12±2.3	4.45±0.97	20.1±1.13
Copper (mg)	2.87±0.68	9.77±1.17	7.65±0.89	5.12±0.78	10.61±1.94	9.06±0.79	1.8±0.89	23.71±3.25
Ascorbic acid (mg)	18±3	10±2	64±6	46±7	70±7	40±9	78±12	55±8

Source: [87]

become harvestable within a short period (usually within 3-4 weeks) makes them useful in supporting nutrition-intervention programmes [79]. These vegetables are readily accessible to the low income communities in rural and urban areas in dryland regions. Moreover, they offer an opportunity of providing affordable nutrition to avert malnutrition in combination with small grain cereals (sorghum and millets) complementing the dietary requirements of individuals. [126] cited in [81] postulated that 'hidden hunger' or malnutrition as a result of micronutrient deficiency afflicts over two billion people worldwide. This has resulted in poor health, low worker productivity, increased rate of chronic diseases (coronary heart disease, cancer, stroke and diabetes) and cognitive abilities of infants born to micronutrient deficiency mothers [126]. AIVs food security is mainly due to their higher nutrient content compared to their counterparts' exotic vegetables [27,8,14]. AIVs contribute significantly towards food security in Southern Africa, especially as a dried form during winter [95].

Consequently, food security cannot be delinked from nutrition security to which consumption of indigenous vegetables significantly contributed [57]. [19] proposed that there is need for investments in AIVs research and development so as to battle against poverty and hunger. Inimitable opportunities are offered through cultivation of AIVs to diversify farming systems so as to ensure food security and are cheap alternatives as compared to their expensive counterparts with lower nutritional value [19]. Table 1 shows examples of selected indigenous vegetables consumed in some parts of Zimbabwe.

4.2 Nutritional Composition of Selected AIVs

[118] and [4] reports on chemical composition of indigenous vegetables and fruits highlighted that they contain important amounts of phytochemicals including crude protein, fat and oil, energy, vitamins and minerals. [96] suggested that AIVs are sources of high quality nutrition. [102] postulated that AIVs are excellent sources of vitamins A and C, and iron, protein, minerals and fibre. These micronutrients are an essential component for people without access to meat or other sources of protein [111].

Several studies have indicated that these vegetables are cheap for rural people and they are said to contain vitamins and minerals in quantities which far exceeds those found in most exotic vegetables [97,118,115].

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Table 4. Nutritional comparison of selected Indigenous vegetables and common exotic vegetables grown in some parts of Africa (Nutrient content per 100g fresh weight)

Nutrient	Indigenous vegetables			Common exotic vegetables				
	Cleome gynandra	*Amaranthus hybridus*	*vigna unguiculata*	*Corchorus tridens*	*Solanum nigrum*	*Kale*	*Cabbage*	*spinach*
Protein (%)	5.1	4	4.7	4.5	4.6	2.5	1.4	2.3
Vitamin (mg)	144	135	87	187	131	93	33	28
Calcium (mg)	262	480	152	360	442	187	44	93
Iron (mg)	19	10	39	7.7	12	32	0.8	32
B-carotene (mg)	2.7	10.7	5.7	6.4	8.8	7.3	1.2	5.1

Modified table: Source [78, 3, 86]

4.3 Challenges in Cultivation of AIVs

Cultivation of African indigenous vegetables is affected by lack of seeds and planting materials. There is overreliance of unimproved landraces i.e self-retained seeds, poor quality seeds and lack of distinct varieties [63]. Some seeds exhibit dormancy during winter periods and resume germination in summer. Currently, there is lack of extension services on agronomic aspects such as planting, optimum spacing, use of fertilisers and manure. Other challenges related to the production of AIVs include lack of technical knowledge, pest and diseases, water requirements and expected yield per hectare. Lack of irrigation facilities in smallholder farmers acts as a barrier in overreliance on rain-fed production making it an unviable enterprise in providing alternative cheap but nutritious relish and a steady income flow.

Perceptions by many households influence the consumption of indigenous vegetables [63]. AIVs are considered to be inferior in their taste as compared to exotic vegetables resulting in reduced frequency of consumption over the years [123]. Poverty and primitive practices are associated with low intake of indigenous vegetables and they are associated with the concept of social backwardness [62]. This explains why young household members shun indigenous vegetables as they are associated with poverty, backwardness and bitterness [123, 130, 35, 89, 7]. Youngsters have active taste buds that are replaced each time of growth. They shun to consume bitter taste foods as compared to adults whose taste buds don't get replaced each time they grow. Intensity of consuming indigenous vegetables is influenced by many other socio economic factors, such as gender, education and age of household head, market options and household monthly income. [123] and [62] as cited in [95] highlighted that men have less preference for consumption of indigenous vegetables than women.

5. Steps towards Improving the Cultivation of AIVS in Zimbabwe

Seed Breeding and Certification

Most farmers are using informal retained seed for subsistence farming. Currently there is no formal breeding of IVs being done for commercial production. There is need to improve high seed quality access that allows holistic varietal selection amongst smallholder farmers. The government of Zimbabwe through the Plant protection unit should ensure that there is proper seed certification by formal seed systems. This will ensure access for smallholder to a wide variety of seeds.

5.1 Improve Current Cultivation Practices

There is need to invest in research and innovation as prescribed in the doctrine of Higher and Tertiary education which spelled out heritage based philosophy 5.0. Farmers should be trained on new techniques by capacity building of extension officers. Researchers and agronomist must create manuals on good practises based on indigenous knowledge to combat pest and diseases so as to disseminate knowledge on commercialisation of AIVs.

5.2 Develop Low-cost, Innovative Technology for Post-harvest Processing

There is need to share knowledge on processing and handling techniques with various community back-

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grounds. Threshing machines, de-saponification machines and affordable cooling and storage technologies should be developed for post-harvest processing.

African Indigenous Vegetables (AIVs) are highly prone to spoilage due to lack of sufficient processing capacity and lack of market due to stiff competition from exotic vegetables [46]. Lack of appropriate production technology has much contribution to the low production of AIVs and poor distribution in Zimbabwe. To curb this problem of AIV spoilage, drying has been an indigenous technology system of processing leafy vegetables to prolong their shelf by preventing spoilage making them available during periods of scarcity. It is of significance to note that production of AIVs with extended shelf life can help reduce losses posed by perishables there by improving the population's income and supply situation. However, sun drying method which is mostly employed to dry these AIVs, often yields poor quality products due to wind dust, microbes and or animals spoilage.

Food engineers have devised the drying equipment used in industrialised countries that curb these problems but it requires a good capital investment and well developed infrastructure [45]. To minimize post-harvest losses and to ensure regular supplies of African indigenous vegetables from the production areas to consumer's market centres, Zimbabwe's economy through the ministry of Agriculture and food security should develop and promote locally appropriate processing techniques which are affordable by the farmers. AIVs suffer under utilisation and under exploitation mainly due to lack of processing amongst other constrains such as marketing and nutritional details [45]. [19] processing plays a very critical role in transforming vegetables from perishable state thereby prolonging their shelf lives which helps in their transportation and distribution within the country and abroad.

5.3 Value Addition and Marketing Improvement

Value addition such as drying, mixed flour of maize and indigenous vegetables so as to prolong shelf life[63]. There is need to increase marketing options through investing inadequate infrastructure and transportation means. Raising of awareness must be done through social media, cooking tutorials on TV. Eco labelling will ensure that there is proper dissemination of information on AIVs in Zimbabwe.

5.4 Holistic Approach to Promote Value Chain of AIVs

[104] and [67] as cited in [63] highlighted that there is need to integrate a holistic approach from genetic diversity, capacity building, seed supply services, cultivation practices, harvest and post-harvest processing, value addition and marketing. This will ensure successful market development in Zimbabwe by promoting value chain of AIVs thereby increasing their consumption and cultivation.

5.5 Improve on Policy Frameworks on Cultivation of Heritage Based Indigenous Vegetables in Zimbabwe

Zimbabwean policy frameworks and decisions are now increasingly emphasizing the importance of traditional food species from a nutritional perspective. The doctrine of heritage based philosophy 5.0 prophesied by the Ministry of Higher and Tertiary Education underlines the need to transform smallholder agriculture from low-productivity subsistence activities to innovative agribusiness enterprises. There is need for persuasive research based information, suitable national legislation and information campaigns on cultivation and consumption of AIVs in Zimbabwe. [128] postulated that research on drought-tolerant crop varieties as well as organic farming is important to achieve the vision 2030 of achieving a middle class economy. Zimbabwe is adopting an education system that imparts knowledge suitable for exploitation of locally available indigenous resources to achieve an industrialised and modernised economy hence promoting mass production of African indigenous vegetables. Marondera University of Agricultural Science and Technology in 2020 was funded by the government to research on sustainable production and commercialisation of indigenous vegetables for suitability in specific food, drink and feed formulation addressing innovation and industrialisation.

6. Opportunities for AIVs

6.1 Livestock Feed

Black jack and gallant soldier can be used as feed for rabbits. [28] pointed out that leaves of spider plants can be used as feed for bovines, camels, equines and game animals. Seed is used as feed for birds. Oil is said to be extracted by simply pressing without complications of refining as indicated [83]. Production of seedcake was also observed by [84] which is used as animal feed.

6.2 Medicinal Properties

[13] cited in [44] indicates that 43 % of the population in sub-Saharan Africa suffers from chronic food shortages and deficiencies of essential nutrients such as iron, vitamin A and iodine.

UN (2010) indicated that roughly one in every three

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children under the age of five years in Zimbabwe is chronically malnourished. Access and intake of adequate nutrients is the predominant challenge which emanates to micronutrient deficiencies as they occur in the presence of adequate energy intake [36]. Medicinal therapy in fighting HIV/AIDS can be supplemented by including AIVs in the diet. [130] highlighted that consumption of AIVs can be important in alleviating malnutrition, improve nutrition and help to alleviate HIV/AIDS.

Bitter gourd (*Momordica charantia*) and tropical pumpkin (*Cucurbita moschata*) are important indigenous vegetables in the tropics and possess good nutrient density. Fruits of bitter gourd are a rich source of β-carotene, vitamin C, folic acid, magnesium, phosphorus and potassium [132]. Its fruits are often used in traditional medicine to treat type II diabetes which is most prevalent in many countries in the South and Central Pacific [127,51]. Tropical pumpkins proliferate in α- and β-carotenes and lutein which a rich source of dietary fiber. As a precursor of vitamin A, β-carotene is required for the proper development and working of the eyes whilst lutein has an important photo-protective function in the macular region of the retina [16].

[116] highlighted that *Cleome gynandra* contains a lot of phenols which can be used to cure cancer, asthma, diabetes and cardiovascular diseases. Currently, reports by several authors indicate that individuals and elderly with complication such as hypertension, diabetes and cancer are mostly prone to Covid-19 pandemic [73,49,33].Therefore, eating *C. gynandra* can reduce such complications as suggested by [116]. Several researchers indicated that spider plant is used to cure migraine, vomiting, diphtheria, vertigo, headache, pneumonia, septic ears, stomach ailments, as eyewash [65,32,110]. [17] suggested that spider plant has ethno medicinal properties such as treatment of piles, rheumatism, anti-tumour activity and malaria [41]. Studies by Imanirampa and Alele (2016 observed antifungal activity of *Cleome gynandra* L. aerial parts for topical treatment of *Tinea capitis*. Findings by [103] hypothesised that boiled drink of the plant can be used as a remedy for scurvy and marasmus and consistent consumption eases pregnant women during child birth [65]. [53] also highlighted that consuming of spider plant by pregnant women reduces labour time also. Results by [88] declared that methanol extraction of spider plant produced total antioxidant potentials. These anti-oxidants bind harmful free radicals which when left in the body may cause diseases such as cancer and diabetes [81].

Black nightshade (*S. nigrum*) is a highly valued as it is consumed for its perceived health benefits and flavour. [61] as cited in [15] indicated that black nightshade leaves are consumed to combat diabetes, high blood pressure, anaemia, peptic ulcers, colds, coughs and sight problems.

6.3 Crop/Plant Protectant

Insecticidal, antifeedant and repellent characteristics have been observed in *Cleome gynandra* [119,120,105,106,114,72,107,9,12,14]. [94] in Kenya observed that intercropping spider plant with roses in greenhouses at 8.3 plants/m^{-2} reduced the populations of red spider mites (*Tetranychus urticae*) and diamond back moth (*Plutella xylostella*) as well as thrip attacks. [38] observed that intercropping spider plant reduced the population of thrips (*Thrips tabaci*) in onions. [28] reported that leaves of spider plant have repellent and acaricidal properties against the larvae, nymphs and adult *Rhipicephalus appendiculatus* and *Amblyomma variegatum* ticks. *Cleome gynandra* aqueous extracts exhibit insecticidal and insect repellent properties which can reduce aphid and thrip populations [110]. Isothiocyanates from spider plant and phenolic compounds and acid volatile oil posses' antimicrobial and insecticidal properties [83, 74].

7. Future Prospects

In response to COVID-19, some of the selected AIVs have great potential to be used in ameliorating its risks. In the review, it is postulated that black nightshade leaves are consumed to combat diabetes, high blood pressure, anaemia, peptic ulcers, colds, coughs and sight problems hence giving room for medicinal studies against this pandemic. *Cleome gynandra* contains a lot of phenols which can be used to cure cancer, asthma, diabetes and cardiovascular diseases. Several researchers indicated that spider plant is used to cure migraine, vomiting, diphtheria, vertigo, headache, pneumonia, septic ears, stomach ailments, as eyewash. This gives researchers the plummet to research on the ethno-medicinal properties of AIVs plant on symptoms of COVID-19.

8. Conclusions

AIVs are excellent sources of micronutrients such as vitamins A and C, and iron, protein, minerals and fibre as compared to their counterparts (exotic vegetables). Micronutrients forms an essential component of dietary requirements of an individual and have a positive impact on COVID-19 outcome as they play a significant role in the immune system. Realisation of UN's proposed Sustainable Development Goal 6 is going to be achieved through a holistic approach of involvement of various stakeholders involved in AIVs value chain. AIVs production has a potential to build capacity and enable rural communities to be resilient against the quirks of climate change impacts, hence ensuring food and nutritional security.

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Recommendations

There is need for persuasive research based information, suitable national legislation and information campaigns on cultivation and consumption of AIVs in Zimbabwe. Productivity of AIVs and small grains in Zimbabwe should be increased in order to ensure nutrition and food security as they are well adapted to changing climate. There is need for training and capacity building of seed and vegetable growers in Zimbabwe. Value chain of AIVs should be strengthened.

Conflicts of Interest

Authors do not declare any conflicts of interest

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