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Recognition of Indigenous Foods and Edible Insects in Nutrition Programs of 16 Member States in the Southern African Development Community (SADC): A Program evaluation

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Abstract:

Background: Communities in most countries of the 16-Member Southern African Development Community (SADC) eat insects including crickets, grasshoppers, cicadas, edible caterpillar, beetles, and locusts. They also consume wild animals including rabbits, mice, wild birds, reptiles like tortoises, and various types of indigenous vegetables to meet their nutritional needs.

Methodology: Several options were utilized for the methodology: First, emails were sent to the national nutrition program officers in the 16 SADC countries; a follow-up second round of emails was sent to countries that did not answer to the first round. This was followed by telephone calls to the program officers as a crosschecking mechanism; a desk review of the national nutritional programs documents; and an internet Google search on the nutritional value of the insects and indigenous foods was done.

Results: The emails, telephone calls and reviews of the national nutrition documents provided lists of indigenous foods recommended by some countries, common staple foods, and indigenous foods available in the SADC region**.** Deficiencies in minerals, vitamins, essential amino acids, micronutrients, and other food content in the staple foods of the communities cause most nutritional disorders in the SADC Region. Anaemia (iron deficiency), stunted growth (micronutrient deficiency), and skin lesions (vitamin deficiency) are some of the common manifestations of diseases caused by deficiencies in diets of the region.

Conclusion: Most Member States in the SADC Region have communities that recognize edible insects and other indigenous foods as part of the food and feed. Studies show that these foods contain high nutritional values. This article recommends the inclusion of indigenous foods in national nutritional programs.

Keywords: Entomophagy/insectivore, edible rodents, deficiencies, game birds, Indigenous fruits.

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Introduction

In 2014 the Region identified nutrition as one of the important and priority areas in its regional cooperation and integration component of the health agenda (SADC Nutrition Report 2014). The SADC Region has approximately 61.8 million under-five population; 4.9 million of these are wasted, 27 million with stunted growth, and 14.2 million undernourished (SADC Nutrition Report 2014). Micronutrient deficiencies are well above most SADC Member States' energy threshold, affecting children's physical and cognitive development (SADC Nutrition Report 2014). Sub-Saharan Africa presents an obvious deterioration in nutrition and poverty indicators (SADC Nutrition Report 2014). Vulnerability to food and nutritional deficiencies is highest amongst children, women, and the poor. The statistics on malnutrition in the SADC Region are quite disturbing: the proportion of malnutrition ranged from 33-35% between 2004 and 2014, under-nourished population ranged from 5-47% (SADC NR 2014). Per capita dietary energy supply was 2,160 instead of the recommended 2,700 kcal, and protein supply at 49g instead of the recommended 68g (SADC NR 2014). Populations in seven countries (which seven? name them) show severe anemia ranging from 40.5-74.7%, with rates of stunting and wasting ranging from 7-39%. (SADC NR 2014). Malnutrition is a public health problem in the SADC region, a 2014, SADC Nutritional Report identified the deficiencies below as nutritional problems in the region (SADC 2014):

1. High rates of under-nutrition
2. Increasing rates of overweight and obesity
3. Maternal under-nutrition
4. Maternal and child malnutrition,
5. Micronutrient malnutrition; Vitamin A, Zinc, and Iron deficiencies (7 of the 16 countries have severe anaemia of 40.5-74.7%). and
6. Under-nutrition; stunting and wasting.

One of the biggest nutritional challenges in the SADC region is essential Amino Acid (AA) deficiencies. Essential AA are indispensable; the body cannot synthesize them and it has to get them from foods. These AA include; phenylalanine, tryptophan, isoleucine, methionine, leucine, and lysine. In SADC countries where maize is the staple food, their diets are deficient in tryptophan and lysine. Caterpillars in the DRC are rich in lysine and the termite species macrotermes belliscosus contains plenty of tryptophan and lysine (Jongema 2014). Micronutrients play an important role in the nutritive value of food. Micronutrient deficiencies have major adverse health consequences; impairment in growth, immune function, mental and physical development, and reproductive outcomes. Minerals play an important role in biological processes and many deficiencies have been observed in the region, on the continent, and in most developing and developed countries (SADC NR 2014). Iron deficiency/anaemia is one of the most widespread nutritional disorders. Anaemia is preventable but still contributes to 20% of all maternal deaths (SADC NR 2014). Most edible insects boast equal or higher iron content than beef (Bukkens 1997). There is need to encourage communities to eat indigenous foods.

Fig. 1: Member States of the SADC Region

Diagram 1. above shows the 16 Member States of the SADC Region comprising of 11 Anglophone (English-speaking), 3 Francophone (French-speaking), and 2 Lusophone (Portuguese-speaking) countries.

Global situations: It is globally estimated that nearly 842 million people or 12% of the global population, were unable to meet their dietary energy requirements from 2010 to 2013 (Van Huis et al. 2013). The vast majority of hungry people, 827 million, live in developing countries, where the prevalence of malnutrition is at approximately 15%. Africa remains the region with the highest prevalence of under-nutrition (Van Huis et al., 2013). Sub-Saharan Africa is the only region where hunger is projected to worsen unless some drastic measures are taken to reverse food insecurity (Van Huis 2016). It is estimated that the world population might reach 9 billion people by the year 2050 and feeding this growing population will become a problem with decreasing arable land and the negative impacts of climate change (Van Huis 2016). There is, therefore, a need to think of alternative food sources and patterns of food consumption, which can combat the food shortage, under-nutrition, and, negative impacts of climate change. The United Nations Food and Agricultural Organization (FAO)(2013 emphasizes that entomophagy/insectivore (consumption of edible insects), and consumption of Indigenous vegetables, wild fruits, wild game birds, and other small animals offer several opportunities including nutritional, environmental, social, and economic benefits. Entomophagy has existed both in the ancestors of Homo sapiens and primitive communities. Coprolites of ancient humans prove that before humans acquired tools for hunting and gathering food, insects were an important part of the human diet. Today, in many parts of the world including Asia, Africa, and South America insects are still part of communities' diets (Bukkens 1997). About 2 billion people, mainly in developing countries including sub-Saharan countries consume globally 1,900 species of insects (Van Huis 2016). In many parts of Africa, Asia, South America, and Australia a wide range of animal products are eaten that may not be common to communities and researchers from Europe and North America (Elorduy 1997). These animals include many different insects, such as locusts, grasshoppers, termites, ants, beetles, caterpillars, small wild animals, small birds including their eggs, and rodents. Indigenous vegetables are consumed in many of these regions of the world. Nearly half of the world has micronutrient deficiency: 25% of children have sub-clinical vitamin A deficiency, 40% of women are anaemic, and 20% have iodine deficiency (Keatinge et al 2015). Increasing dietary diversity and the intake of vegetables and fruits is widely recognized as a key strategy to address the deficiencies in micronutrients. Rats and rodents are part of the diet in many countries in Asia including China, the Philippines, Cambodia, and Laos to name a few, and in most African countries and in South America (Oyarekua 2010). Recent studies show that they have important nutritional values (Oyarekua 2010). Malnutrition remains the global most serious health problem and the single biggest contributor to child mortality, yet largely predictable and preventable. Hidden hunger caused by micronutrient deficiencies, especially iron, vitamins, zinc, and iodine deficiencies contributes to direct impacts on the mortality rates of women and children (Keatinge et al 2015).

Entomophagy in Africa: Insects exist in abundance throughout the African continent and are part of the staple food of many indigenes. Insects play a significant role, as food and feed, especially during the rainy season when hunting game or fish becomes problematic (Van Huis 2013). The Ngandu people and other communities of the Democratic Republic of Congo obtain nourishment from what is seasonally available especially wild gathered plants, mushrooms, mammals, birds, fish, reptiles, wild fruits, and edible insects. The DRC boasts of an abundant all-year-round supply of caterpillars, with the average household in Kinshasa, the capital, consuming 300g of caterpillars a week. It has been estimated that 96 tons of caterpillars are consumed in Kinshasa annually (Kitsa 1989) In Madagascar caterpillars are harvested from the forests at the end of the dry season and utilized especially in times of food shortage. In southern Africa, emperor moths (Saturniidae) are widely consumed during food–deficient periods of the year. People in all the 16 countries in the SADC region practice entomophagy in one way or another but unfortunately, most of this information is undocumented. Insects are found in abundance everywhere and reproduce quickly. According to a survey by ICIPE, Southern Africa boasts 164 edible insect species second to the central African region, which has 256 species. Edible insects are a natural renewable food source providing all nutrients: carbohydrates, proteins, fats, minerals, and vitamins. Edible insects can therefore offer an opportunity to bridge the protein gap of human foods. Insects are also rich in fiber, and micronutrients such as copper, iron, magnesium, phosphorous, selenium, and zinc. Insects pose a lower risk of transmission of zoonotic diseases from animals to humans such as SARS, HINI, COVID-19, EBOLA, and BSE (mad cow disease) to name a few (Belluco et al 2023). In general, most insects are believed to be good sources of iron and zinc, whereas beef averages 12.5mg/100mg, the palm weevil (rhycophotus phoenicis) contains 26.5/100 iron content (Bukkens 1997). Mopane worms have an iron content ranging from 31-77mg/100g, and locusts 8-20mg/100g both more than 100g of beef. Zinc deficiency is another core public health problem, especially in child and maternal health. Zinc deficiency causes growth retardation, delayed sexual and bone maturation, skin lesions, diarrhea, alopecia, impaired appetite, and increased susceptibility to infections via defects in the immune system (Rajkhowa et al 2016, Latunde-Dada et al 2016). Most edible insects and some wild fruits and indigenous vegetables contain enough recommended dietary allowances (RDA) (Xiamong et al 2010, Hui (ed.) 2006). Protein-energy malnutrition (PEM) is a big challenge in most developing countries. Insect proteins are highly digestible between 77% and 98 % (Elorduy 1997). Nutritionally insects are comparable to conventional animal protein sources such as beef and fish. Crickets for instance contain 60% protein, 20% fat, 20% fiber, and 450kcal/100g. (Rumbold et al., 2013). Insects are the most abundant multi-cellular organisms on earth and are thought to account for more than 70% of all species (Kelemu et al., 2015). The nutritional content of the insects depends on the stage of metamorphosis (stage of life of the particular insects), habitat, and diet. Insects can provide high-quality proteins and nutrients comparable to meat and fish. Most insects are high in fatty acids and could be utilized as food supplements for under-nourished children. Insects most eaten in Africa are dominated by the orders Lepidoptera, orthopteran, and Coleopteran (Kelemu et al., 2015). African edible insects are both for food and feed (Van Huis 2013). Capinera (2008) has classified the percentage of edible insects globally as follows Coleoptera (beetles) 13%, Lepidoptera (caterpillars) 18%, Hymenoptera (bees, wasps, and ants) 14%, Orthoptera (grasshoppers, locusts, and crickets)13% , Hemiptera (cicadas, leafhoppers, scale insects, and true bugs) 10%, Isoptera (termites) 3%, Odonata (dragon flies) 3%, Diptera (flies) 2% and, others 5%. Recent research (Van Huis 2016, Srivastava et al 2009, and Elorduy 1997) has shown edible insects provide proteins including amino acids such as methionine, is not essential in humans, lysine, and threonine, histidine, isoleucine, leucine, phenylalanine, tryptophan and valine, carbohydrates, fats, some minerals, and vitamins, and have energy value (www.Fruits info.com, www.Wikipedia.org).

Methodology

Four approaches were utilized, first, emails were sent to program officers of the 16 member states of the SADC region. These had three simple questions:

1. State indigenous foods recommended in the brochures and your national nutrition program.
2. State some of the Indigenous foods consumed by communities in your country.
3. What is the staple food of your country?

This was a convenience sample of all the 16 Member States. The second approach was a follow-up to the emails, with a telephone call to all 16 Member States even after they had answered the emails. This was to crosscheck the answers from the emails. The third approach was to review the national nutrition programs of the 16 Member States crosschecking on the foods recommended in each program. Lastly, an internet search on the nutritional values of the common indigenous foods in the region. There was no need for ethical considerations and approval from any boards. There was no need of a special statistical analysis method since simple arithmetic sufficed. A convenient sample of the 16 Member States of the SADC Region was preferred to get data from all countries. There was no need of using a statistical program for the results, simple arithmetic sufficed.

Results

Ten member States (62.5 %) of the Member States replied to the first emails. The second sets of emails were sent to the last six Member States had not replied the first time and three Member States (50% of the remaining six) replied to the emails. The 16 phone calls to all member states were successful in that we were able to talk to everyone and could get the required information. The most common staple foods included maize meal called sadza in Zimbabwe, paletshe in Botswana, South Africa, and Lesotho, pap (Afrikaans) in South Africa, Ugali in Tanzania and prepared from milled maize. Maize meal contains fiber, pro-vitamin A or carotenoids, vitamin E, calcium, iron, magnesium, phosphorous, potassium, zinc, selenium, copper, manganese and some protein with low lysine AA], however, it should be fortified with tryptophan and lysine. Cassava is very popular in countries like DRC, Malawi, Mozambique, and Zambia. The other countries rely on rice most of which is imported with a few mainland countries producing indigenous brown rice. Wheat bread is one of the most popular foods in all 16 Member States with most of it being processed bread. The Island member states and those with coastal areas also consume a lot of seafood including fish, mussels, shrimps, lobsters, and frogs. Indigenous foods for communities in the SADC region include insects, vegetables, wild fruits, reptiles, rodents, and sweet potatoes (Van Huis 2013). Edible insects found in the region include a variety of ants, Christmas beetles, crickets, locusts, caterpillars, mopane worms, and termites (Van Huis 2016). Wild fruits include a variety of plums, monkey oranges, loquats, figs, morula, Indian jujube, and African chewing gum (www.fruitinfo.com). Reptiles include a variety of lizards, tortoises, and snakes. Wild bird and their eggs include doves and other small birds, ostriches, and guinea fowl. Rodents include rats, mice, rock rabbits, and grass cutters. There are several varieties of vegetables in the SADC region including, pumpkin vegetables, watermelons, beans, legumes, delele, and plenty other green vegetables found in the wild (Mushaphi FL 2022). All the 12 mainland countries also use millet, sorghum, and Rapoko or finger millet as a staple food, but these are not recognized as such by nutrition programs. Most indigenous foods in the region are harvested from the forests and are not part of the commercial farming industry, but there are insect farms in some SADC countries including Botswana, Zimbabwe, and South Africa., SA check attached literature). Table 2 below shows the results of the responses from national nutrition programs officers, and reviews of the national nutrition programs of the SADC Member States.

Table 1: Results of the reviews of the SADC nutrition programs and responds from national program officers. Compilation Chipfakacha V.G. 2022 (provided by Member States and literature review)

Member State	Foreign food	Indigenous Food	Foreign Fruits	Indigenous Fruits
Angola	Yes	Caterpillars	Yes	None
Botswana	Yes	Yes (Mopane)but rest foreign foods	Yes	None
Comoros	Yes	None	Yes	None
Eswatini	Yes	None	Yes	None
DRC	Yes	None	Yes	None
Malawi	Yes	Cassava and indigenous vegetables	Yes	None
Lesotho	Yes	None	Yes	None
Madagascar	Yes	None	Yes	None

Mauritius	Yes	None	Yes	None
Mozambique	Yes	None	Yes	None
Namibia	Yes	None	Yes	None
Seychelles	Yes	None	Yes	None
South Africa	Yes	None	Yes	None
Tanzania	Yes	None	Yes	None
Zambia	Yes	Yes; indigenous vegetables and edible insects.	Yes	None
Zimbabwe	Yes	Black Jack, poor man's spinach	Yes	None

Discussion:

There are plenty of edible insects, wild fruits, indigenous leafy vegetables, game birds, rodents, and small wild animal with higher nutritional values and micronutrients available in the 16 Member States of the SADC Region. These indigenous foods are not formerly documented in an informative manner, which could bring awareness amongst the region's communities. In fact, some people despise indigenous foods such as reptiles, rodents, small game, and wild fruits preferring alien foods, because they have no knowledge of the value of their indigenous foods. It is disappointing that indigenous foods are not the preferred choice of nutritious foods in nearly all the national nutrition programs of the Member States of the SADC Region, as shown in Table 1 above. The SADC region boasts of many indigenous foods that are not expensive and contain all the required nutrients. Unfortunately, not many studies and publications are available for both communities and nutritionists on the nutritional values of indigenous foods. Malnutrition is still a big problem in several SADC Member States, and one of the reasons is that communities cannot afford the foods recommended by the Ministries responsible for Health and Nutrition. Out of the 16 Member States, only 3 countries (Botswana, Zambia, and Zimbabwe), have one or two indigenous foods in their nutritional programs. Indigenous foods are affordable, easily accessible, and accepted in most communities, however, some people are not willing to eat indigenous foods because they think European foods are better. In pre-colonial Africa, food existed in abundance; wild fruits existed in the forests, there was a wide variety of edible insects and indigenous vegetables grew in an organic environment. Game birds and small animals were also abundant in the forests and available freely for the communities. There were no restrictions to land acquisition or hunting of wild animals, harvesting of wild fruits and edible insects and vegetables. Colonialism brought with it many restrictions to the African communities; they lost their fertile lands ending up in barren non-productive areas with overcrowding. Legislation limited access to wild animals, wild vegetables, reptiles, game birds, and edible insects. There is no documentation of malnutrition during the pre-colonial era, but there is evidence of severe malnutrition during the colonial period, and particularly in post-colonial Africa (Rijpma1996). Communities in the pre-colonial period did not eat processed foods, processed foods become available only during the colonial and post-colonial periods; globalization made it worse during the last few decades. Organic food with no chemical fertilizers was the food during pre-colonization, refined sugars did not exist; Communities utilized honey and other natural sweeteners. Entomophagy, the consumption of insects by humans, is practiced in many parts of the world especially in Africa, Asia, Latin, and South America (Van Huis 2013). Approximately two billion people worldwide supplement their diets with insects (FAO, 2013). Insects in many parts of the world including the SADC region are an ideal staple food component of the diet. Insects are the most abundant organisms on the planet. They are highly nutritious (Bukkens, 1997). The nutritional content of insects depends on the stage of metamorphosis/stage of life, habitat, and diet. Insects can provide high-quality protein and nutrients comparable to meat and fish. Most insects are high in fatty acids and can therefore be used as food supplements in under-nourished children. Insects are also rich in fibers, and micronutrients such as copper, iron, zinc, magnesium, phosphorous, and selenium. The practice of eating insects also known as entomophagy is globally widespread. They offer many advantages including (FAO 2013):

- Insects play an important role in health, providing a nutritious alternative to mainstream staples, and completely organic with no added chemicals.
- Many edible insects are rich in proteins, good fats, and high in calcium, iron, and zinc
- Land farming is not a land-based activity and does not need clearing to expand production. Feed is a major requirement for land Ammonia emissions associated with insect farming are much lower than those linked to conventional animal husbandry did.
- Insects are cold-blooded, 4 times less than cattle, and are therefore efficient in converting feed into protein (crickets need 12 times less than sheep and half as much feed as pigs and broiler chickens to produce the same amount of proteins)
- Insects can be fed on an organic waste stream.

Entomophagy played an important role in the history of human nutrition in Africa (Van Huis 2013) In recent times edible insects have gained plenty of attention because of their high nutritional value and environmental advantages over meat production (Van Huis, 2016). Insects are also easily available and cheaper making them accessible and affordable for the poorest of the poor. (Van Huis, 2016). Commonly consumed edible insects globally, include Coleoptera (beetles) 31% consumption, Lepidoptera (caterpillars) 8% consumption, Hymenoptera (bees, wasps, and ants) 14% consumption, orthopteran (grasshoppers, locusts, and crickets) 13% consumption, hemipteran (cicadas, leafhoppers, and true bugs) 10% consumption, isopteran (termites) 3% consumption, odonatan (dragonflies) 3% consumption, dipteran (flies) 2% consumption and others 5% consumption (Jongema 2014). Insects are a group with the highest number of available species in nature representing significant biomass. The following are some of the nutritional contents of edible insects found in the SADC Region: Mopane worms/caterpillars. (Fig 2, 3, and 4) have a protein content of 48-61% and a fat content of 16-20% of which 40% are essential fatty acids. Mopane worms are also a good source of micronutrients such as calcium, zinc, and iron. Mopane worms are not merely, “feminine foods”, but also form a regular part of the diet of communities in Botswana, Namibia, South Africa, Zambia, and Zimbabwe. Insects' short life cycles, low land space requirements, efficient nutrition equivalent rates, and lower greenhouse gas production render them to be, in principle, an excellent alternative to meat substitute.

Fig 2. Fresh Mopane worms

Fig 3. Cooked Mopane worms

Fig 4. Caterpillars

Caterpillars constitute 50-60/100g protein, are rich in fat and iron content of between 27-35g/100g. Termites play an important role in nutrition in most SADC countries on the mainland. Many studies (Van Huis 2016, Kinyuru et al 2011, Latunde-Dada 2016) on termites have shown their high nutritional value which consists of moisture, protein, fat, total ash, dietary fiber, and carbohydrates. Studies by Kinyuri et al (2011) show that the termites macrotermes Sublanus (MS) Pseudocantho termes militaris (PTM), macrotermes bellicosus (MB), and pseudocantho termes spiniger (PTS) contain these very important nutritional values in good quantities. The same termites contain important micronutrients; MS contains 58.78 mg calcium, 33.33 mg iron, and 8.10 mg zinc, PTM 43.31 mg calcium, 1.60mg iron, and 12.86 zinc. M constitutes 63.60 calcium, 115.97 iron, and 10.76 zinc, and PTS contains 42.48 mg calcium, 64.77 mg, and 7.10 mg zinc (Kinyuru et al 2011). Termites that are harvested in abundance during the rainy season could play an important role in providing micronutrients to communities; Micronutrient deficiencies are major public health problems in the SADC region. They contain high-quality nutrients including highly digestive protein as well as minerals, which are more bio-available than minerals from plant food (Omotoso, 2008). Crickets have higher quality animal protein than some conventional sources such as fish and are more affordable among poor communities (Kipkoiech et al., 2017). Of the 14 edible cricket species every 100g of dry weight has a protein value ranging from 18.6-71.1%, lipids 4.30-33.44%, tryglycerols 80%, phospholipids >20%, ash 2.96-20.50 mg, and fiber including chitin (0.5-13.4% (Kelemu et al 2014, Rumbold et al 2013). Tables 4 and 5 below show Essential amino acids (EEA), non-essential amino acids, and vitamin contents of some edible crickets. The micro-mineral elements such as aluminum, cobalt, copper, iron, manganese, and zinc in edible crickets are higher in content compared to micro-mineral elements in beef, chicken, and pork (Homan et al., 2016).

A study of iron bioavailability found in eating b.bimaculatus cricket can enable one to meet a high percentage of human-recommended daily iron intake (Latunde-Dada et al., 2016).

The number of vitamins in edible insects collected from the wild is determined by the season and the meal of the insect. Crickets are poor sources of Vitamin A, Vitamin C, Niacin, and in most cases thiamine (Rumbold et al., 2013). Humans have used crickets for therapeutic functions since ancient times. Recent studies have shown that crickets can be utilized as a traditional remedy for fever and high blood pressure (Ahn et al., 2014). Cricket legs are ground into powder, dissolved in water, and then taken as a drink to relieve dropsy (oedema) (Rajkhowa et al., 2016). In Nigeria, the intestinal content of mole cricket, gryllotalpa Africana Beauvais, is applied to patients suffering from athletes' feet for treatment (Forasanti et al., 1997). Research has shown the utilization of ground crickets as a supplementary diet to fight deficiency diseases such as marasmus and kwashiorkor (Homan et al., 2016). The results have shown that the incorporation of cricket powder in the diets of schools for growth and learning enhancement. The presence of essential amino acids including valine, lysine, threonine, and methionine. Some edible crickets help in breaking down saturated fatty acids, which are implicated in lifestyle conditions such as obesity, hypertension, type 2 diabetes mellitus, and cancer in human beings (Ahn et al., 2004). Studies by Henlay et al (2020) show that the essential amino acid composition of different edible crickets g/10o are much higher than those in pork loin for instance Valine EAA ranges from 2 to

12 g/100, Isoleucine EAA 2.5 to 5 g/100, Lysine EAA 2.5 to 8 g/100, threonine EAA 2 to 3.9 g/100, phenyl amine EAA 0.71 to 3.10 g/100, methionine EAA 0.63 to 3.00 g/100, and tryptophan EAA 0.55 to 2.44 g/100. The following are simple amino acids histidine 1.32 to 2.26 g/100, tyrosine 1.00 to 5.44 g/100, arginine 0.32 to 6.10 g/100, aspartic acid 3.72 to 8.64 g/100, glutamine acid 2.41 to 19.25 g/199, serine 0.62 to 3.72 g/100, asparagine 3.27 to 6.3 g/100, glycine 0.36 to 4.72 g/1oo, alanine 0.14 to 8.85 g/100, cysteine 0.74 to 5.10 g/100, proline 1.15 to 4.52 g/100, and taurine 1.23 to 141 g/100. Crickets also provide a wide range of high-level vitamins including Retinol (Vit. A), B-carotene, thiamine (Vit, B1), riboflavin (Vit.B2), niacin (Vit.B3), pantothenic acid (Vit.B5), pyridoxine (Vit B6), biotin (Vit.B7), folic acid (Vit. B9), Vitamin C, Vitamin K, Vitamin E, and choline Henlay et al 2020)

A Study by Allotey and Mpuchane (Kinyuru et al., 2011) shows that the longhorn grasshopper (Ruspollia differens) contains significant proportions of proteins, fats, and other nutrients. Consumption of 100g of this insect contributes significantly to the recommended daily requirements of retinol, a-tocopherol, niacin, riboflavin, and folic as well as iron, zinc, calcium, and potassium. Kinyuru et al 2011, in their studies, showed the nutritional values of some grasshoppers (figs 8, 9, and 10) eaten by communities in Kenya.

Fig 8. Green grasshopper

Fig 9 Common African Grasshopper

Fig 10 Brown Grasshopp

The Green grasshopper (Ruspolia differens)(Fig.8), contains the following minerals on dry weight basis mg/100; calcium 27.4, magnesium 33.9, potassium 360.6, sodium 358.7, phosphorous 140.9, iron 16.5, zinc 17.3, manganese 5.3, and copper 0.6. The brown grasshopper (Ruspolia differens) (Fig.10) contains the same mineral on dry weight mg/100; calcium 24.5, magnesium 33.1, potassium 259.7, sodium 229.7, phosphorous 121.0, iron 13.0, zinc 12.4, manganese 2.5, and copper 0.5. Both green and brown grasshoppers have important vitamin content; the green grasshopper retinol 2.1 ug/g, a-tocopherol 201.1ug/g, niacin 2.1 mg/100g, riboflavin 1.2 mg/100g, ascobic acid 0.1 mg/100g, folic acid 0.9 mg/100g, and pyridoxine 0.4 mg/100g (Kinyuru et al 2011). The brown grasshopper on the other hand has the following vitamin content; retinol 2.8 ug/g, a-tocopherol 152.0 ug/g, niacin 2.4 mg/100g, riboflavin 1.4 mg/100g, ascorbic acid 01 mg/100g, folic acid 0.9 mg/100g, pyridoxine 0.2 mg/100g (Kinyuru et al 2001). Grasshoppers can be collected from the grasslands free or sold cheaply at the market, making them alternative foods to alien foods. Grasshoppers also contain the following fatty acids; capric acid, lauric acid, myristic acid, palmitic acid, stearic acid, oleic acid, linoleic acid, linoleric acid, total saturated fats, total unsaturated fats, mono-unsaturated fats, and poly-unsaturated fats. The presence of fatty acids especially Linoleic and Linolenic acid; points to the nutritional value of the grasshopper oils. Grasshoppers also contain considerable quantities of thefollowing lipid cales; neutral lipids, phospholipids, and glycolipids. Table 10 below shows lipid classes in some grasshoppers (Kinyuru et al 2011). Table 2 below shows the range of proteins in some insect orders.

Table 2: Protein range in percentages in some insect orders.

Insect order	Stage of growth	% range of protein
Coleoptera	Adult and larvae	23-66
Lepidoptera	Pupae and larvae	14-68
Hemiptera	Adult and larvae	42-74
Homoptera	Adult, larvae and eggs	45-57
Hymenoptera	Adult, pupae, larvae and eggs	13-177
Odonata	Adult and naiad	46-65
Orthoptera	Adult and nymph	23-65

Source: Van Huis 2013

Fig 16: Masawu (Indian Jujube

Fig 17 Hacha (mobola plum)

Fig 18 Moroja/African chewing gum

Fig 19 Monkey Orange (Damba)

Fig. 20: Cluster fig

Fig. 21: Morula Fruit

Fig 22. Mazhanje (wild loquat)

Fig 23: tsvanzva (sour plum)

Fig 24 Hute (water berry)

The common cluster fig which is found in abundance in the SADC region and harvested by communities contains the following nutritional values with the % daily value (DV) in parenthesis; calcium 72 mg (% DV 72.0), iron1,3 mg (%DV 16.25), magnesium 35 mg (%DV 8.33), phosphorous 47 mg (% DV 6.71), potassium 508mg (%DV 6.71), sodium 23mg (%DV 10.81), zinc 0.3 mg (%DV2.73), copper 0.1 mg (% DV 11.11). The figs also contain the following vitamins; o.o5 mug retinol/Vit.A (% DV 4.17), 0.4 mug thiamine/Vit.B1 (% DV 0.77), 0.2 mug riboflavin/Vit. B 2 (% DV 1.25), and 1.0 mug ascorbic acid/Vit.C (% DV 11.11) (**http//ndb.nal.usda.gov/2016)**. Matufu or false wild medlar is another important fruit of southern Africa: besides medicinal qualities it also has nutritional values that include ash 22.65g/100g), calcium (0.7mg/100g), carbohydrates (77.07%), crude fiber (10.0g/100g), crude protein (3.07-21.50 g/100g), copper (5.9-10.1mg/100g), and energy (1445 k-joules/100g) (Healthline.com). Matufu also contains many phytochemicals and anti-oxidants. The Morula Fruit and Seeds is also important in brewing a special alcoholic drink. The nuts of the Morula fruit contain minerals such as iron, magnesium, zinc, phosphorous, copper, protein, and energy. The Morula fruit also has important nutritional values: protein (23.3g/100g), fat (57.3g/100g), fiber (2.9g/100g), energy (2703kl/100g), calcium (118mg/100g), magnesium (462mg/100g), iron (4.87mg/100g), sodium (3.81mg/100g), potassium (601mg/100g), copper (2.81mg/100g), zinc (5.19mg/100g), Thiamin(0.42mg/100g), riboflavin (0.12mg/100g) and nicotinic acid (0.72mg/100g). Tsambatsi (Wild Grapes) provide Vitamins B1, B6 and C, and minerals such as manganese and potassium. They are also an excellent source of anti-oxidants. Children eat a lot of these whilst herding cattle. (www.specialityproduce.com>produce>wild_grapes_16539.) The other fruits that are also of great importance in Southern Africa include, water berry, and wild loquat. Mazhanje (Water berry) contains amongst other valuable nutritional products 270 mg of sodium, which is equivalent to 12% of daily value (DV), 70mg potassium equivalent to 1%DV, and 30mg Vitamin C equivalent to 33%DV (6). Wild loquat contains total fat equivalent to 1% DV, carbohydrates equivalent to 12% DV, dietary fiber 12% DV and protein 75g/100g.

Most African communities consume rodents and other small animals as food. The species eaten vary from antelope to monkeys, rodents, reptiles, and a whole range of invertebrate species including snails, termites, and beetles. Rodents are particularly important in terms of range of species, and numbers taken, possibly because they are not subject to hunting restrictions in many countries, and the fact that their high reproductive capacity makes them relatively more abundant. Species such as monitor lizards, frogs, toads, turtles, tortoises, and several species of snakes including venomous ones such as the puff adder are regarded as delicacies among many African communities in Southern Africa (FAO, 2013). The African giant rat/mouse has the highest value of phospholipids especially in the brain. It contains plenty of iron in all parts of its body, higher than the required daily Giant rat limb muscle has high values potassium, zinc, and manganese, with higher phosphorous values. However, organ examinations in the mouse and giant rat showed low calcium levels. Tables 3,4, and 5 below show some chemical and mineral compositions of the African rat/mice.

Table 3: Proximate chemical analysis of Mice/African giant rats

Nutrient per 100g	Skin	Muscle	Liver	Brain
Moisture	56.8	65.4	62.1	72.8
Crude Protein	8.7	20.1	18.39	12.3
Fat	9.8	11.4	10.2	5.6
Ash	7.9	2.0	5.7	6.2
Carbohydrate	16.7	1.0	3.7	3.2

Source: Oyarekua 2010

Table 4: Mineral composition of Mice/Giant African rat

Mineral mg/100g	Skin	Muscle	Liver	Brain
Calcium	93.3	50.0	30.3	57.0
Potassium	993.8	1387.5	1162.5	1312.5
Phosphorous	750	750	1500	1650.0
Iron	70	73	167.8	95.8
Zinc	8.5	175	15.5	11.8
Magnesium	200	26	105.0	22,53

Source: Oyarekua 2010

Table 5: Individual lip. Cholesterol, and free fatty acid composition of Mice/African giant rat

Lipid mg/100g	Skin	Muscle	Liver	Brain
Mono-glycerol	5.0		150.0	20.0
Diacly- glycerol	50.0	50.0	30.0	Not detected
Cholesterol	150.0	70,0	140.7	60.0
Free fatty acid	150.0	20.0	150.6	50.0
Phospholipids	173.20	182.4	185.4	198.4

Source: Oyarekua 20

The tortoises is a reptile that is a delicacy in some communities and table 17 below shows nutrient values of the tortoise that the human body requires. Meat from small animals such as wild rabbits, grass cutters, and hares also provide high nutritional value to community diets

Tortoise meat contains the following nutritional value; 197 calories of energy, 16.5 mg of protein, 13.4 mg of fat, 0.5 g carbohydrates, 94 ug retinol/vitamin A, 3.6 ug Vitamin D, 1mg Vitamin E, 5 ug Vitamin K, 0.91 mg Vitamin B1, 0.41 mg Vitamin B2, 3 mg Niacin, 0.11 mg Vitamin B12, 1.2 hg Vitamin 6, 0.2 pantothenic acid, 1 mg Vitamin C, 69 mg sodium, 18 ug calcium,150 mg sodium,10 mg magnesium, 88 mg phosphorous, o.4 mg copper, o.o2 manganese and 1.6 mg zinc (www.Slism.com. 2020). Wild or bush meat provides a major source of proteins for tropical forest people around the world. In the Democratic Republic of Congo (DRC) wild meat has been estimated to contribute 30%-80% of the protein intake for forest-dwelling people and some people from rural areas and other countries of the SADC Region. West African giant snails (archachatina marginata) are the most important sources of protein in many rural areas. In rural areas with poor access to the markets, wild animals often constitute the cheapest and sometimes the only available type of protein available. In Southern Africa, rodent meat is a major component of people's diets, including native game birds such as Guinea fowls, partridges, quails, francolins, sand grouse, pigeons and doves, snipe as well as sixteen species of waterfowl.

Fig 28: Guinea fowls

Fig 29: Doves

Fig 30: Ostrich

Guinea fowls are easily accessible in rural communities and are consumed when caught by guinea fowl hunters. 100g of guinea fowl meat contains the following nutritious value with % daily value (DV in brackets); 18 g (% DV 35), 94 kilo calories of energy, 59 mg sodium (% DV3.00), and 54 mg (%DV 18) (www.nutrifox.com 2023). Guinea fowl eggs are rich in vitamins; one guinea fowl contains more vitamins than a single chicken egg. These eggs, for instance, have Vitamin A, Vitamin D, vitamin B6, and Vitamin K. The eggs also contain several minerals such as calcium, folate, selenium, and phosphorous. Vitamin A in guinea fowls is beneficial for enhancing vision, reproduction, and strengthening the immune system. High in healthy cholesterol, guinea fowl eggs contain 212 mg of the healthy cholesterol. Diabetic patients can consume guinea fowl eggs without severe side effects. Guinea fowl legs have a high amount of choline, a vital nutrient that most people lack in their bodies. Choline is beneficial in building cell membranes. One guinea fowl egg contains around 100mg of choline that could provide plenty of choline required by the human body. Guinea fowl eggs have less fat as compared to eggs of birds, chickens, and ducks. Table 21 below shows the nutritional value of ostrich eggs. Guinea Fowl eggs are nutritious, packing more nutrients than chicken and duck eggs (Gamal R et. all 2022).

Guinea fowl eggs for instance have loads of vitamins compared to chicken and duck eggs. The yolk of these eggs is high in potassium, sodium, and iron. Because of their richness in potassium, Guinea fowl eggs can help regulate muscle contraction, nerve signals, and fluid balance (Gamal R et al 2022). Several countries in the SADC countries are domesticating the Guinea fowl as well (Moreki et al 2013). 140 grams of cooked dove meat contains 298 calories, 18 grams of fat, 33 grams of protein, no carbohydrate, 80 mg sodium, 33 g protein, 59 mg sodium, 54 mg cholesterol, 24 mg calcium, 8.3 mg iron, 358 mg potassium, and 0.3mcg Vitamin D. Ostrich meat and ostrich eggs are easily available to most communities in the SADC Region although in some countries hunting these birds is regulated. Ostrich meat also contains vitamins, minerals, saturated fats, and other micronutrients with a high percentage of daily values, ostrich eggs contain saturated fats, proteins, minerals, and calories (Moreki 2021). The ostrich although originally a wild bird has become a big farming bird in most African countries since its introduction in South Africa from 1857-1860 (Moreki et al 2021). Both ostrich meat and ostrich eggs could provide nutrients to communities. Some of the nutrients from 100g of raw ostrich meat include 0.2mg Vitamin E (% DV 2), 0.2mg thiamine (%15), 0.30 riboflavin (% DV 21), 4.40 niacin (%DV 27), o.50 mg Vitamin B6 (%VD 28), 4.60 mg Vitamin B12 (% 192), 5mcgDFE folate (% DV 2), 1.10 pantothenic acid (%DV 22), 200mg phosphorous (% VD 16), 10mg calcium (% DV 1.00), 20mg magnesium (% DV 5), 3.50 mg zinc (% DV32), 33 mg selenium (% DV 60), 0.10 mg copper (% DV 14), 0.0001 manganese (% DV1.00), 2.9 mg iron (% DV 16), 72 mg sodium (% DV 4), 71 mg cholesterol (% DV 24), 1932 mg potassium (% DV 41), and 3 grams of protein (www. Recipal.com). Eggs of many wild birds including guinea fowl and ostriches are highly nutritious and rich in vitamins, minerals, and choline required by the human body (Gamal et al 2022). A 1400g Ostrich egg contains the following nutrient value; 133g total fat (% DV171), 44g saturated fat (%220), 5208mg cholesterol (%DV1738), 1988mg sodium (% DV86), 10g total carbohydrate (%DV 4), 1932mg potassium (% DV 41), 176g protein, 2002 kcalories, 25g polysaturated fat, and 5g monosaturated fat (Gamal 2022).

Fig 31: Guinea Fowl Eggs

Fig 32: Wild bird's eggs

Fig 33: Ostrich eggs

Indigenous vegetables, legumes, and tubers. Wild vegetables found in most SADC Member States in abundance have phytonutrients such as carotenoids, pro-vitamin A, flavonoids, phenolic acids, etc. (Mushaphi 2022) to name a few. Wild mushrooms contain high levels of vitamins, and minerals (Medical news today 2021). Recommending indigenous foods and wild fruits would assist in improving the nutritional value of the communities of countries in the SADC Region. Most communities suffer from a lack of micronutrients and minerals in their diets and end up with illnesses such as anemia, stunted growth, maternal and child under nutrition, and overweight and obesity. Vegetables are low in fat, salt, and sugar and provide energy, vitamins, minerals, and fire. Starchy vegetables especially root and tubers including cassava, maize, potatoes, and yams contain high levels of carbohydrates.

Most of these starchy foods are staple foods in the SADC Region. Peanuts are legumes rather than nuts. They offer a good source of mono-saturated fats, polyunsaturated fats, proteins, and B vitamins. One half-cup of raw peanuts (73 grams) o contains 414 calories, 18.9 grams of proteins, 45.9 grams of fat, 11.75 grams of carbohydrates. 6.2 grams of fibers, Thiamine (Vitamin B1) 39% of DV, Niacin (Vitamin B3) 55% of the DV, Folate (Vitamin B9) 44% of the DV, Vitamin E (41%of the DV), Iron (19% 0f the DV, Magnesium (29% of the DV), and manganese (61% of the DV). Due to their content of mono-saturated fats, peanuts have several health benefits especially if they replace other dietary components. In the SADC region communities use peanuts for different purposes including as cooking oil, peanut butter, or pounding into small pieces to spice vegetable and meat dishes. Plants produce phytonutrients for protection from insects, bacteria, and other germs. These are naturally occurring in plants, examples including lycopene in tomatoes, beta-carotene in carrots, and glucosinolates in broccoli. Research shows that phytonutrients may work in lots of different ways to protect against diseases and promote health. The most protective effects come from eating a wide variety of phytonutrients as they occur naturally in plant food, and the body cannot synthesize them and none can be manufactured either. Figures 31 to 37 below show some of the indigenous vegetables consumed in the SADC Region.

Fig 31: Cassava

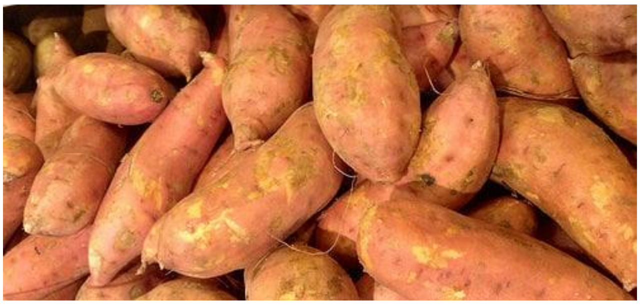

Fig 32: Sweet Potatoes

Fig 33: Peanuts

Fig.34: Pumpkin

Fig 36: Pumpkin leaf

Fig.37 Maize/Corn

Fig 38 Wild Mushrooms

Sweet corn is a staple food in most of the SADC countries and is utilized as a meal, roasted corn or cooked in different dishes. Both pumpkin leaves and their flowers are a relish in most countries, including the fruits that then become pumpkins.

Some of the classification of vegetables in the SADC Region include bulbs (shallots, fennel) roots (sweet potatoes, cassava), flowers (pumpkin and squash), fruits (loquats, monkey oranges), fungi (wild mushroms, truffle), leaves (pumpkin, squash, cassava), seeds (a variety of beans, pumpkin), stems (sweet reed), and tubers (wild potatoes, and a variety of yams) (Mushaphi et al 2022). The vegetables in the region provide the following phytonutrients carotenois, pro-vitamin A, aloha-carotene, beta-carotene, beta-cryptoxanthin, lycopene,xanthophylls,lutein, zeaxanthin, glucosinokates, isothiocynates, flavor noids, phenolic acids, anthocynanins, allium sulfur compounds, betalains, falcarinol, falcarindiol, falcarinol, falcarindiol, saponinins, phytosterols, fructants, and capsaicinoids (Mushaphi et al 2022).Wild mushrooms (fig 38) are found in abundance in most forests of the SADC region with many species found in termite nests. They are consumed fresh during the rainy season with some dried ones cooked during the dry season. The following are nutritional value of a 96 g-cup of African wild mushrooms/fungi; 21.1 kilo calories of energy, 3 g protein, 3.1 g of carbohydrates, 2.9 mg calcium,0.5 mg of iron,8.6 mg magnesium, 82.6 mg phosphorous, 305 mg potassium, 4.8 mg sodium, 0.5 mg zinc, 305 mg copper, 8.9 mg selenium, 0.2 mg Vitamin D, 20 mg vitamin C, 16.6 mg choline, 3.5.mg Niacin, and 20mcg DEF folate (Gbologade et al 2006, Sileshi et al 2023). The nutrient value of these edible fungi/mushrooms range from 3-100% of daily-recommended intakes. Legumes (fig.39) are one of the most consumed foods by most people in Africa and the SADC Region. Legumes provide fiber, protein, b-vitamins, iron, copper, magnesium, manganese, zinc, and phosphorous. They have a low glycemic index generally ranging between 10 and 40. Legumes are generally low in fat, and practically free of saturated fats, and because they are plant foods, they are cholesterol-free (www.helthline.com 2023). One serving of legumes provides 115 calories, 20g of carbohydrates, 7.9 g of fiber, 8g of protein, and 1g of fat (www.Healthline.com 2023) . Beans are part of the diets of African communities and are part of the legume family. Beans provide protein, fiber, folate, iron, potassium, and magnesium while containing little or no fat, trans fat, sodium, and cholesterol. 1 cup of /168 grams of beans contains 5.68 grams of protein, fat 104 grams, carbohydrate 3.5g, 148mg of potassium, 118mg of phosphorous, 86mg of magnesium,12mg of calcium, 1,34mg iron, and also vitamins including thiamin, riboflavin, niacin, folate, Vitamin K, and vitamin B-6. (www.nutrifox.com). Beans provide complex carbohydrates, also referred to as dietary starch; these are made of sugar molecules strung together like a necklace. Complex carbohydrates are typically rich in fiber. Being rich in complex carbohydrates, as well as being a good source of protein, beans have a low glycemic index. This makes them an ideal food for the management of insulin-resistant diabetes and hyperlipidemia (Rani Polak et al 2015). Beans are rich in both soluble and insoluble fiber, soluble fiber traps dietary cholesterol, and insoluble fiber, which assist in trapping water for the human stools. Cowpeas are another great source of fiber and protein. One cup (164g) of cooked cow peas contains 269 calories, 14.5 grams of proteins, 4.25 grams of fat, 45 grams of carbohydrates, 12.5 grams of fiber, folate (Vit B9) 71 % of DV, copper 64% of DV, manganese 73% of DV, and iron 26% of DV (Jayathilake et al 2018). Lentils are one of the most iron-rich legumes. One cup (198g) of cooked lentils contains 230 calories, 17.9 grams of proteins, 0.752 grams of fat, 39.8 grams of carbohydrates, 15.6 grams of fiber, Thiamine (Vit B1) 30 of the daily value (DV), folate (Vitamin B9) 90% of the DV, Copper 55% of the DV, Iron 35% of the DV, Zinc 23% of the DV. (Savage). It should be noted that deforestation/land clearance/desertification is fast leading to the extinction of indigenous trees and with them the insects, reptiles, birds, small wild animals, and rodents that co-habit in these forests. Rural-urban migration has also resulted in the younger generations growing without the knowledge of indigenous foods viewing them as primitive foods. The young generation lacks the knowledge of names of animals, insects, vegetables, small game birds, and rodents, especially when indigenous languages are excluded from school curricula. This might also be the reason why these foods are not recommended in current national nutrition programs. Roman-Dutch law legislation by post-colonial governments prevents communities from harvesting some of these foods, robbing them of their traditional heritage.

Conclusion

In all SADC Member States, there is inadequate documentation of indigenous foods, and if documented there is inadequate knowledge sharing, management, and dissemination to communities. There is also limited collaboration between sectors such as agriculture and ministries responsible for health; this lack of collaboration also exists amongst the Member States of the region including limited funding for harnessing regional surveys and studies on these indigenous foods. Nutritional programs should add indigenous foods to the alien foods that most programs recommend currently; these foods should be listed according to their nutritional values. Studies from Kenya and South Africa have proven the nutritional values of indigenous foods. This should assist countries to add indigenous foods rich in carbohydrates, vitamins, minerals, and other micronutrients to their national nutritional program lists. Communities should be encouraged to use the easily accessible, acceptable, and affordable indigenous foods. This could have a major impact on the problems of under nutrition and deficiency diseases affecting the region.

Recommendations:

- SDC Member States should collect and compile information on the nutritional value of all Indigenous foods available in their countries and add them to their national nutrition programs. The region should also research foods including edible insects, and small animals consumed by communities, particularly in the rural areas to ascertain their nutritional values.
- Countries compile information on all Indigenous foods, translate it into relevant vernacular languages, and disseminate the information to communities so they understand the nutritional value of their indigenous foods.
- Ministries responsible for agriculture in collaboration with the United Nations Food and Agricultural Organization (FAO) including the Ministries responsible for Health and Nutrition should invest time, effort, and other resources on indigenous foods. An example is what was done in Zambia between the Ministry of Agriculture and FAO in developing a compendium of all indigenous foods in Zambia, their nutritional value and how to store and prepare them to preserve their nutritional value.
- There is a need to use edible insects in managing protein-energy malnutrition (PEM) using edible insects as studies by Bukken SG and FAO have shown, they are cheaper than the current foods used in most countries.
- Countries should start measuring the amounts of edible insects, indigenous fruits, and vegetables harvested every year in order to develop policies to regulate the harvesting of these foodstuffs to limit their destruction as has happened to some biodiversity, in some countries.
- The SADC Region should routinely commission regional surveys and studies on indigenous foods of the region with a clear dissemination strategy and knowledge management of the outcomes.

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