

## **The Importance of Brassica Vegetables to the Kingdom of Eswatini: A Review**

**Michael T. Masarirambi<sup>1\*</sup>, Kwanele A. Nxumalo<sup>1</sup>, Daniel V. Dlamini<sup>2</sup>,  
Lokadhia Manwa<sup>3</sup> and Molyn Mpfu<sup>3</sup>**

<sup>1</sup>*Department of Horticulture, Faculty of Agriculture, University of Eswatini, P.O. Luyengo M205, Luyengo, Eswatini.*

<sup>2</sup>*Department of Agricultural Economics and Management, Faculty of Agriculture, University of Eswatini, P.O. Luyengo M205, Luyengo, Eswatini.*

<sup>3</sup>*Department of Consumer Science Education and Community Development, Faculty of Consumer Sciences, University of Eswatini, P.O. Luyengo M205, Luyengo, Eswatini.*

### **Authors' contributions**

*This work was carried out in collaboration among all authors. Author MTM designed the study, performed the statistical analysis, wrote the protocol and wrote the first draft of the manuscript. Authors KAN, DVD, LM and MM managed the analyses of the study. All authors read and approved the final manuscript.*

### **Article Information**

DOI: 10.9734/CJAST/2020/v39i1730758

#### Editor(s):

(1) Dr. Chien-Jen Wang, National University of Tainan, Taiwan.

#### Reviewers:

(1) Jubilee Purkayastha, Institute of Nuclear Medicine and Allied Sciences (INMAS), Defense Institute of Physiology & Allied Science, India.

(2) K. Sudha Rameshwari, V. V. Vanniaperumal College for Women, India.

Complete Peer review History: <http://www.sdiarticle4.com/review-history/57651>

**Review Article**

**Received 10 April 2020**

**Accepted 15 June 2020**

**Published 03 July 2020**

### **ABSTRACT**

Brassica vegetables are diverse and widely consumed in tropical, subtropical and temperate regions of the world. Although exotic in Southern Africa brassicas are now relatively important vegetables produced and consumed in the region all year round. In their production, postharvest handling, storage and processing chain, employment is created and revenue is generated and thus their contribution to gross domestic product (GDP). Brassicas are not only important economically but by far their greatest contribution is to human nutrition and health. They contain vitamins and cancer preventing phytochemicals. They also contribute fibre which is important for proper digestion and is anticancer preventing material. Brassica vegetables provide interesting colour when incorporated in salads. They are components which add up to achieving food security in the Kingdom of Eswatini. Despite immense importance of brassica vegetables in the Kingdom, there is dearth of information pertaining to their agro-climatological requirements and their nutritional

\*Corresponding author: E-mail: [mike@uniswa.sz](mailto:mike@uniswa.sz);

awareness among the citizens. Therefore, the purpose of this study was to explore the agro-climatological needs of the brassica vegetables and to bring awareness of their health and food security contribution through documentation and community education.

**Keywords:** *Brassica vegetables; economic importance; GDP; food security; health benefits; climate smart vegetables; Sustainable development goals (SDGs).*

## 1. INTRODUCTION

Brassicas also known as Cole crops are a diverse assortment of leaf and root vegetables which are grown and consumed in the whole world. They belong to the mustard family (Brassicaceae) informally referred to as cabbages or cruciferous vegetables [1-7]. The genus brassica is one of 51 genera in the tribe Brassicaceae belonging to the Crucifer family and is economically the most important genus within the tribe, containing 37 different species [8]. They are thought to have originated in the Mediterranean shore line. Many crop species include edible roots, stems, leaves, buds, flowers and seeds. In Africa and Asia, cabbage (*Brassica oleracea* var *capitata*) for example, remains a very important crop for smallholder farmers providing income, nutrition and enabling small farms to remain financially viable, especially in the rapidly growing peri-urban farming sector [9].

The Kingdom of Eswatini formerly known as the Kingdom of Swaziland is located in Southern Africa and is a member of the Southern African Development Community (SADC). Agriculture is the backbone of the economy of the Kingdom of Eswatini and is a source of employment for more than 70% of the population [10,3]. Agriculture is important to the Kingdom for nutritional and food security. Baby brassicas apart from being consumed locally can be exported and thereby bringing in the much needed foreign currency. There have been reports of declining gross domestic product (GDP) [11,5]. The GDP is viewed as the engine for economic growth (World Bank, 2011). One way of boosting GDP is through increased brassica vegetable production both conventional and baby types. The purpose of this study was to explore the potential of brassica vegetable production in the Kingdom of Eswatini in order to alleviate unemployment, poverty, malnutrition and food insecurity.

## 2. METHODOLOGY

The researchers employed a qualitative approach. Desk review of existing literature was done and informal surveys were carried out in the four agro-ecological zones of the Kingdom of Eswatini [12].

## 3. FINDINGS AND DISCUSSION

### 3.1 The Kingdom of Eswatini

The study was carried out in the Kingdom of Eswatini formerly the Kingdom of Swaziland which is comprised of four agro-ecological zones namely Highveld, Middle-veld, Low-veld and the Lubombo region (Fig. 1). Eswatini a member of the Southern African Development Community (SADC) covers an area of about 17, 364 km<sup>2</sup>, lies between latitudes 25° 43' and 27° 19' S, longitudes 30° 47' and 32° 08'. It is a landlocked country surrounded on the north, west and south by South Africa and on the east by Mozambique [13].

The Highveld has a near temperate climate. Temperature ranges from 4, 5° to 35°C [14]. The Middleveld temperature ranges from 2.5 to 37.2°C [14], has fertile valleys which favour intensive farming and is the most populated area in the country. Further East is the Lowveld and then the Lubombo plateau, the climate of the Lubombo plateau is similar to that of the Middleveld.

Brassicas can be grown all year round in the Highveld, Middleveld and Lubombo region when suitable cultivars are used. In the Lowveld cabbages can be grown in the winter months also known as the cool season (The CAPM Project, 1996/7) [15].

### 3.2 The Brassicas

There are several leafy brassicas which are grown or can potentially be grown in the Kingdom (Table 1) [16]. There are also underground organ brassicas which can be grown in the four agro-ecological zones (Table 2) [17] at varying times. It is important to note that the underground organ brassicas are not widely popular among indigenous Africans.

### 3.3 Production

Generally the climatic requirements of brassica vegetables are those of cool season vegetables. The optimum temperature for production is

between 15°C to 18°C with a low of 5°C and a maximum of 25°C [1-7]. There is a risk of bolting if vernalized between 4 to 10°C. High temperatures as those prevailing in the Lowveld of Eswatini and in summer in most parts of the Kingdom present a challenge in the production of brassica vegetables. Cultivars differ in response to high temperature tolerance. Elsewhere plant breeders have developed brassica cultivars which are tolerant to relatively high temperatures [1,3,4,6].

Heavy soils with high organic matter (OM) are preferred. The ideal pH is between 6.0 to 7.5 [1-7]. Acid soils such as those found in most parts of Eswatini are not ideal. In such cases a fertiliser with lime maybe necessary in order to raise the pH. In most cases in the various agro-ecological zones vegetables are top dressed with limestone ammonium nitrate (LAN) [15]. Most nutrients are largely available at slightly acidic to neutral pH.

Seeds are planted in a nursery bed and seedlings are planted in rows 60 to 75 cm apart with an intra row spacing of about 45 cm. About 300 to 400 g of seed per hectare are required. The brassica vegetables or Cole crops have high water requirements. Irrigation is necessary if soil moisture gets to less than 60%. Soils have to be of good drainage to avoid water logging [1-7].

### 3.4 Physiological Disorders

Various physiological disorders of brassica vegetables which are encountered in the Kingdom of Eswatini have previously been reported [12]. Physiological disorders of brassicas are abnormalities in leaf and stem morphology, colour or both which are not caused by insect pests or infectious diseases. Reported causes of physiological disorders include environmental factors, genetic, nutrition and cultural practices such as irrigation and tying leaves (blanching) for curd protection in cauliflower (Table 3) [12]. The prevalence of physiological disorders and their intensity differ in the four agro-ecological zones of the country and are affected by seasons. Physiological disorders reported include pre-mature bolting of *Brassica juncea*, head splitting in head forming brassicas, failure of or small multiple head forming called blindness, riciness in cauliflower, oedema, internal tip burn, black petiole, pepper sport, vein spot in cabbages [12]. Physiological disorders found Eswatini are shown in Table 3. Cultivars differ in susceptibility.

### 3.5 Crop Protection

Brassica vegetables need to be protected from insect pests, diseases, nematodes and weeds [1,3,4,6]. Chemicals may be used, however their

**Table 1. Taxonomic classification of some Brassicaceae family vegetables**

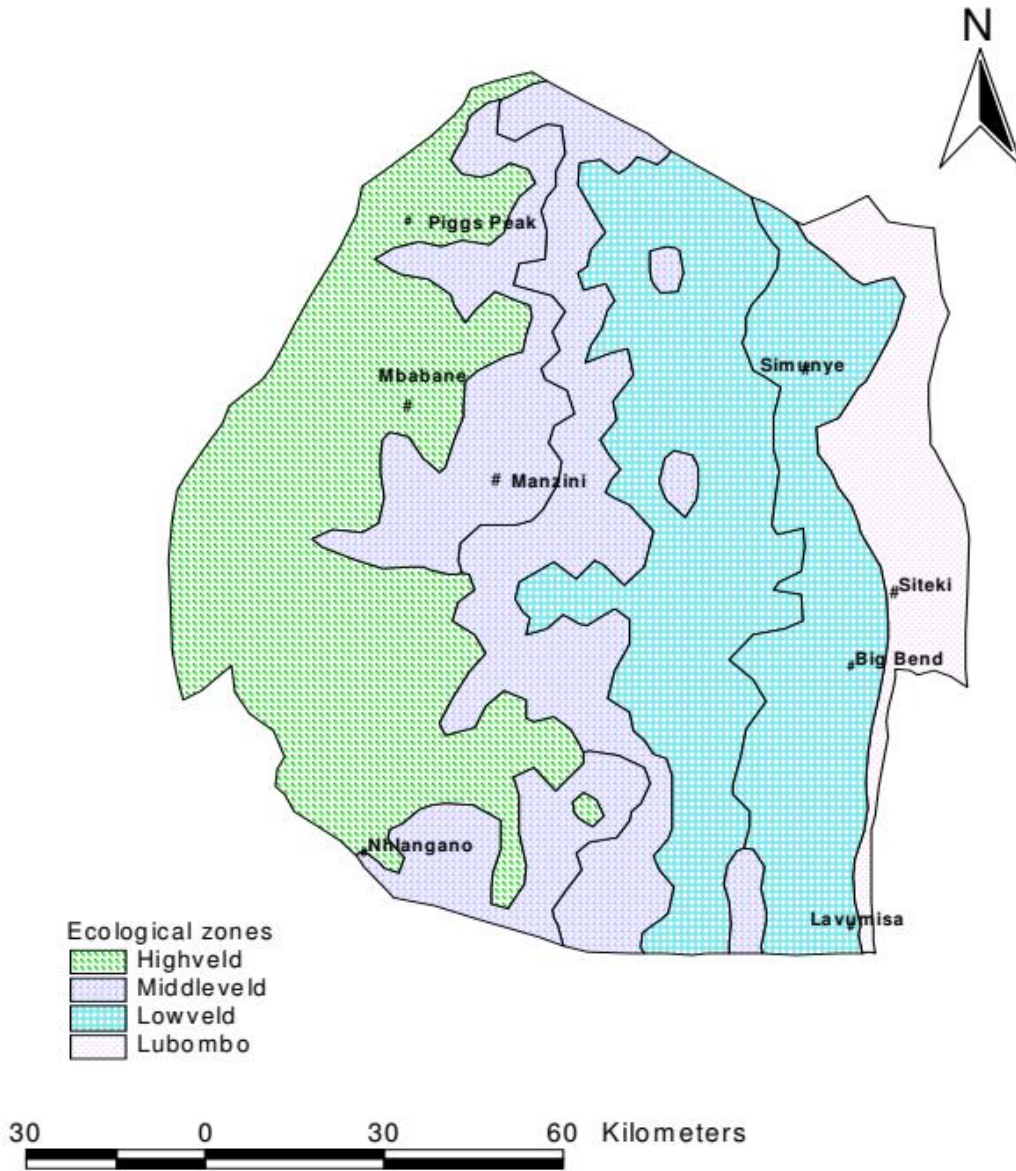
Common name	Scientific name
Broccoli	<i>Brassica oleracea</i> var. <i>botrytis</i>
Brussels sprouts	<i>Brassica oleracea</i> var. <i>gemmifera</i>
Cauliflower	<i>Brassica oleracea</i> var. <i>botrytis</i>
Cabbage	<i>Brassica oleracea</i> var. <i>capitata</i>
Chinese cabbage	<i>Brassica rapa</i> var. <i>pekinensis</i>
Collards and kale	<i>Brassica aoleracea</i> var. <i>acephala</i>
Kohlrabi	<i>Brassica oleracea</i> var. <i>gongylodes</i>
Mustard greens	<i>Brassica juncea</i>
Turnip greens	<i>Brassica rapa</i> var. <i>rapifera</i>
Watercress	<i>Nasturtium officinale</i>

Source: [16, 17]

**Table 2. Taxonomic classification of some underground storage Brassicaceae vegetable organs**

Common name	Genus and species
Horse-radish	<i>Armoracia rusticana</i> P. Gaertn. [stn. <i>Nasturtium armonracia</i> (L.) Fries]
Radish	<i>Raphanus sativus</i> L. var. <i>radicula</i>
Rutabaga	<i>Brassica napus</i> L. var. <i>neobrassica</i>
Turnip	<i>Brassica rapa</i> L. var. <i>rapifera</i>

Source: [17]



**Fig. 1. Ecological zones of Swaziland**  
Kingdom of Eswatini: Source [13] and Google maps

use has to be judicious. Minimum use of chemicals is advocated. Alternatively integrated pest management (IPM) is an option while biological control is a panacea.

### 3.5.1 Insect pests

Insect pests of brassicas include diamond black moth (*Plutella xylostella*), webworm (*Hellula undalis*), red spider mite (*Tetranychus* spp), aphids (*Brevicoryn ebrassicae*). They can be controlled using pesticides on the market or

through IPM [1-4] while biological control where possible will be the ideal control method. In fact organic production of brassicas will be the best for both local and export markets. Organically produced vegetables fetch premium prices in the markets.

### 3.5.2 Diseases

Brassicas suffer from numerous diseases. Therefore crop rotation is necessary in order to break disease cycle. Cabbage or related crops

(broccoli, cauliflower, Brussels sprouts and turnips for example) should not be planted more than once every two to three years in the same field [15]. Diseases include black rot (*Xanthomonas campestris*) which is exacerbated by wet conditions, is seed borne and can be spread through livestock manure. Damping off is caused by *Pythium* and *Rhizoctonia* fungi, there is need to treat seeds, sow thinly and to avoid over-watering. Downy mildew is caused by *Peronospora parasitica* which affects seedlings and is promoted by cool wet weather. Club rot is caused by *Plasmodiophora brassica*, which is soil borne and may persist for seven years. There are various postharvest diseases of Brassica vegetables. Management of postharvest diseases of vegetables in a tropical and sub-tropical environment of the Kingdom of Eswatini has previously been reported [18]. Disease management included those of leafy and root Brassicas [19]. Genetic manipulation can be used as a tool of disease management [20,21]. The use of ethylene control technologies and suppression of gene expression of cell wall degrading enzymes pectin methyl esterase (PME) and polygalacturonase (PG) has potential postharvest benefits environmentally, physiologically, pathologically and entomologically [21].

### 3.5.3 Weed control

Control of weeds is very important throughout the growing season if good yields of high quality produce are to be obtained [15]. Herbicides may safely be used to control weeds. Herbicides have to be used judiciously to avoid crop damage and environmental contamination in order to partly strive to achieve SDGs pertaining to planet earth. Mechanical weeding and or biological control of weeds are better alternatives as they guarantee a clean environment.

### 3.6 Harvesting and Storage

The time taken from transplanting seedlings to harvest depends on the agro-ecological zone and or the season the brassica vegetable is grown. In the Highveld it takes between 80 to 100 days while in the Lowveld between 70-90 days and yields ranging from 12 to 35 tonnes per hectare [1,3,4,6,15]. Multiple harvests may be required. It is important to avoid delays. There is need for careful handling for long term storage. Storage conditions should be near 0°C and about 95% relative humidity (RH). Storage for six

months is possible under ideal conditions of refrigeration and controlled atmosphere (CA) storage conditions.

### 3.7 Seed Production

One of the challenges in brassica vegetable production is that the seeds are imported. Importation of seeds requires foreign currency which is a scarce commodity. On the other hand imported seeds might not have been bred for conditions which prevail in the country. It is therefore recommended that brassica seed production programs be initiated in the country as is done in the United Kingdom [22], Japan [23] and elsewhere. Local seed production will not only bring employment in the country but will help grow the GDP again.

### 3.8 Nutritional Value

Generally Brassica vegetables are of relatively low nutritional content however increased volume of consumption compensates. The nutritional value of Brassica or Cole crops has previously been described [3] Brassica vegetables contain Vitamins A and C, Calcium (Ca), dietary fibre and anti-carcinogenic compounds [1-7].

By far the most contribution of vegetables including brassicas is to proper human nutrition. Brassica vegetables are generally not good sources of carbohydrates because of relatively low content. Brassica vegetables are generally not good sources of protein or fat because of low content.

Vitamins are the major contributions of brassica vegetables to the human diet. Vitamin A  $\beta$ -carotene is converted to Vitamin A which is essential for proper eye sight. Vitamin A is fat soluble and is supplied by brassica leafy vegetables. Its recommended daily requirement is one mg per day [1,3,4,6].

Brassica vegetables are rich in Vitamin C which is water soluble, quantity eaten is important. People in communities are encouraged to eat ample quantities of brassica vegetables in order to obtain healthy quantities of Vitamin C. the recommended requirement is 30 mg/day for an adult. Brassica vegetables contain minerals which are important to human diet. Calcium and phosphorous are supplied by brassica vegetables [1,3,4,6]. Brassica vegetables supply iron which is a competent of haemoglobin that constitutes blood particularly red blood cells.

**Table 3. Physiological disorders of Brassicas/cole crops found in Swaziland**

<b>Crops</b>	<b>BL</b>	<b>BN</b>	<b>BD</b>	<b>BS</b>	<b>BU</b>	<b>BM</b>	<b>BT</b>	<b>BR</b>	<b>VS</b>	<b>TB</b>	<b>NS</b>	<b>HS</b>	<b>LF</b>	<b>RC</b>	<b>WT</b>
Cabbage	*		*	*	*	*			*	*	*				
Brussels sprouts	*		*	*	*	*			*	*	*				
Cauliflower	*						*	*		*		*	*	*	*
Broccoli	*						*	*				*			
Leaf mustard		*													

*\*Occurance of disorder.*

*BL-Blindness; BN-Bolting; BD-Boron deficiency; BS-Black speck; BU-bustling; BM- Black midrib; BT- Buttoning; BR-Browning; VS-Vein streaking; TB-Tip burn; NS-Necrotic spot; HS-Hollow stem; LF-Leafiness; RC-Riciness; WT-Whiptail*

*Source: [12]*

### 3.9 Fibre Roughage

Brassica vegetables are major sources of fibre in the diet. Fibre is important for the proper function of the digestive system which prevents colon cancer. From an aesthetic point of view brassica vegetables provide interesting colour, texture and variety [1,3,4,6]. For example both conventional and baby red cabbage provide interesting colour in salads.

### 3.10 Economic Importance

Economics is concerned with trade, industry and development of a country, an area of society [24]. Economic importance is difficult to assess because statistics are not always available. A vegetable production concern provides employment. Not only employment, but decent jobs are created as enshrined in the sustainable development goals (SDGS). This is crucial for the unemployed youths in the Kingdom of Eswatini. Employment brings income which reduces poverty, crime and improves food security at household and community levels. The vegetable enterprise has to be profitable in order to be sustainable. The profitability of vegetables in the country has been previously reported [25,26,27,28]. Therefore both conventional and baby brassica vegetable production is profitable in the country and thus can alleviate poverty.

Export vegetables like baby brassicas generate the much needed foreign currency. Vegetables are exported regionally and overseas. Over two decades the gross domestic product (GDP) has been declining [10,11]. By increasing the production of vegetables in the country including brassica vegetables helps to contribute to the GDP and improve the economy of the country. When the economy of the country improves so is the standard of living of the residents.

Compilation of monthly statistics in the vegetable industry is a requirement. The National Agricultural Marketing Board (NAMBoard) [29]. NAMBoard regulates the marketing of agricultural products: Imports, exports and transit of scheduled agricultural products, helps small scale farmers to develop their business NAMBOARD provides an outlet for the produce of farmers in the Kingdom of Eswatini. Some vegetables including brassica vegetables are imported into the country mostly from South Africa. The idea is to reduce imports and boost local production so that revenue generated circulates in the country.

There have been campaigns to promote baby vegetables including baby brassicas for export by the Food and Agriculture Organisation (FAO). Stakeholders involved in baby vegetable production include private producers from small scale farmers, big companies and parastatals like Eswatini Agricultural Water Development Enterprise (ESWADE). ESWADE is a government company that facilitates the planning and implementation of the Komati downstream development project (KDDP) and the Lower Usuthu smallholder irrigation project (LUSIP) and any other large water and agricultural development project that government may assign.

### 3.11 Financing

Any project like the promotion of brassica vegetable production for local consumption or export requires financing. There are various financial institutions like banks and development institutions like the Industrial Development Company of Eswatini (IDCE) [27]. The IDCE is a development finance institution that promotes industrial growth in the country. Brassica vegetable producers in the Kingdom of Eswatini can seek the advice of extension officers pertaining to financing of inputs among other needs [28].

### 3.12 Challenges

Food based approaches specifically for the brassica or cruciferous vegetables are usually long-term oriented and more sustainable than other strategies which include nutrient supplements [30]. Increasing the production and intake of micro-nutrient rich foods will go a long way in maintaining the health status of the population. Increased intake of a variety of micro-nutrients improves bioavailability of these nutrients leading to good health through nutrient-nutrient interaction. The provision of quite a number of essential micronutrients may address deficiency problems in the population since the functional interactions between vitamins and mineral elements can also enhance the body's ability to absorb nutrients and overcome micro-nutrient inadequacies.

Brassica or cruciferous vegetables are some of the vegetables which most people, including the Eswatini population have ignored and shun. Most people like vegetables if they are appealing to the eyes and have a favourable taste. Several researches have shown that taking a variety of

vegetables combats micro-nutrient deficiencies [31]. It is therefore of great importance that people be conscientised of the health benefits of these vegetables as they are easily available but underutilised in Eswatini. The main issue is to stop managing malnutrition but dealing with it through the use of these multi-nutrient vegetables. The population's life can change with clean eating and utilisation of vegetables such as those of the Brassica family. The reality is that Africa, as a continent is still facing numerous challenges which include more than 257 million people who are undernourished [32]. This situation could be addressed by consumer education in different platforms as the use of sufficient quantity of healthy brassica vegetables in a sustainable manner may go a long way to solve malnutrition problems.

The major question is what should be prioritised and what unique strategies should be engaged so as to ensure a healthy nation and continent at large? The answer to the question is nutrition education. Nutrition education which is not just learning about foods and nutrients but also learning what to do and how to act to improve nutrition is the way to a healthy society [32]. Consumer education and the promotion of healthy eating behaviours and lifestyles are essential to Eswatini's population health and well-being. Healthy, well-nourished citizens are better able to reach their full physical potential (long-life without diseases). Nutrition choices that people make today can dramatically affect their health and well-being tomorrow. Nutrition concepts therefore need to be reinforced throughout the country and continent. Food and nutrition security, that is, the demand for health consciousness to prevent malnutrition, which is a high risk factor in developing countries like Eswatini especially in the rural areas.

### 3.13 Nutritional Benefits of Brassica Family or Cruciferous Vegetables

*Cabbage* is a low calorie vegetable, it contains vitamin C, folic acid, potassium, vitamin B-6, calcium, biotin, magnesium and manganese. Along with its nutrient content, cabbage also contains the powerful anti-cancer compounds. Cabbage is effective in the treatment of peptic ulcers [33,34]. Actually early use of cabbage was medicinal, a treatment for gout, stomach problems, deafness, headache and hangovers [4].

#### 3.13.1 Cabbage vegetable nutritional facts

Cabbage is packed with vitamin, minerals, carbohydrates, proteins and antioxidants. The nutritional value of cabbage per 100 grams (3.5 Oz), percentage of RDA (Recommended Dietary Allowance) is shown in Table 4.

Nutritional benefits of the various brassica vegetables have previously been described [1,3,4,6]. The potential nutritional benefits of selected individual Brassica vegetables will subsequently be considered.

*Cauliflower* contains relatively less nutrients than the other cruciferous vegetables in the family. It is an excellent source of vitamins C and K. It is also a very good source of potassium, fibre, phosphorus and B vitamins. Cauliflower is a good source of the trace mineral boron and like other members of the family, contains several cancer fighting phyto-chemicals in the form of glucosinolates [1,3,4,6].

*Broccoli* contains a variety of vitamins and mineral elements [1,3,4,6]. One cup of steamed broccoli contains 74 mg of calcium, plus 123 mg of vitamin C, which significantly improves calcium's absorption. It also offers a bulky, 1359 mcg of beta-carotene and small but useful amounts of zinc and selenium, trace minerals that play vital roles in immune system health. A cup of broccoli has 44 calories and supplies 94 mcg of folic acid, a critically important B vitamin, especially necessary for pregnant women to ensure a healthy foetus.

*Brussels sprouts* have similar nutritional qualities as broccoli [1,3,4,6]. They are a great source of folic acid, vitamins C and K, and also beta carotene. They provide plenty of vitamin B-6, fibre, thiamine, potassium and those all-important cancer-fighting phyto-chemicals.

*Kale* is an excellent source of vitamins B-6 and C, carotenes, and manganese. Kale is also a very good source of vitamins B-1, B-2, and E, fibre, iron, copper, calcium and phosphorus. Kale and collard greens exhibit the same anti-cancer properties as other members of the cruciferous family [1,3,4,6].

*Radishes* and their greens provide an excellent source of vitamin C [1,3,4,6]. Radish leaves contain almost six times the vitamin C content of their root and are also a good source of calcium. Daikon radishes provide plenty of potassium and copper. Like other members of this plant family,



**Table 4. Nutritional content of cabbage per 100 g**

<b>Energy</b>	<b>103 kJ (25 kcal)</b>
Carbohydrates	5.8 g
Sugars	3.2 g
Dietary fiber	0.1 g
Fat	2.5 g
Protein	<b>Quantity</b>
<b>Vitamins</b>	
Thiamine (B1)	(5% of RDA) 0.061 mg
Riboflavin (B2)	(3% of RDA) 0.040 mg
Niacin (B3)	(2% of RDA) 0.234 mg
Pantothenic acid (B5)	(4% of RDA) 0.212 mg
Vitamin B6	(10% of RDA) 0.124 mg
Folate (B9)	(11% of RDA) 43 µg
Vitamin C	(44% of RDA) 36.6 mg
Vitamin K	<b>Quantity</b>
<b>Minerals</b>	
Calcium	(4% of RDA) 40 mg 1.28 g
Iron	(4% of RDA) 0.47 mg
Magnesium	(3% of RDA) 12 mg
Manganese	(8% of RDA) 0.16 mg
Phosphorus	(4% of RDA) 26 mg
Potassium	(4% of RDA) 170 mg
Sodium	(2% of RDA) 0.18 mg
Zinc	

Source: [35]

they also contain cancer-protective phytochemicals. Fresh radish roots contain a larger amount of vitamin C than cooked radish roots.

*Mustard greens* are an excellent source of many vitamins [1,3,4,6], including vitamin A, vitamin C, folate, and vitamin E. They also offer an excellent source of the mineral manganese and plenty of B-6, calcium and copper. They are also a very good source of phosphorus, vitamins B-1 and B-2, magnesium, protein, potassium, and iron. Mustard greens provide fibre and are low in calories and high in antioxidants.

Although brassica or cruciferous vegetables may not be as delicious as most people perceive and like, they have ample amounts of healthy nutrients. It is advisable to consume as much quantities as possible in order to attain the daily requirements [1,3,4,6,32,33,35-42]. Various preparation methods may be used to improve their organoleptic taste.

### 3.14 Importance of Nutrition Education

The importance of nutrition education as a means for improving nutrition of the community in the developing countries is the only way to eradicate malnutrition and disease in Eswatini.

Lack of awareness about the dietary requirements and nutritive value of different vegetables is the main cause for prevailing malnutrition among the population with the under-five year olds, pregnant women and lactating mothers being vulnerable sections of the community [43,44]. Nutrition consumer education should be more practical and should be easily adaptable to the socio-economic status, food habits and the available local food resources such as the brassica vegetables. Nutrition consumer education program, as much as possible, should become a part of every society [44]. It may assist in promoting lifelong healthy eating habits of the population and going beyond boundaries, involving families and the community.

### 3.15 Food and Nutrition Security

To sustain food and nutrition security, the use of the brassica family vegetables is the first and foremost idea. At The World Food Summit [42] food security was defined as “a situation that exists when all people, at all times, have physical, social and economic access to sufficient, safe and nutritious foods that meets their dietary needs and food preferences for a healthy life.” Food availability, accessibility,

utilization and stability are the four internationally recognized pillars of food security [45-50]. When the quality of a stored vegetable crop is not maintained there will be food loss and waste and the subsequent impact on food and nutritional security [36,37,38,39].

Food and nutrition security does not just address the availability of food, but it also addresses its cost, cultural appropriateness, the balanced nature of its protein, fat, carbohydrate and micro-nutrient make-up, its source and the production practices used to cultivate and harvest food products, as well as freedom from contamination after harvest [37,38]. Attainment of food and nutritional security are some of the goals enshrined in the SDGs of the United Nations.

#### 4. CONCLUSION

Several brassica vegetables are grown in the four agro-ecological zones of the Kingdom of Eswatini. They are successfully grown all year round in the Highveld, parts of the Middleveld and the Lubombo region. They can be grown in most parts of the country including the Lowveld in winter because they are cool season vegetables. They are important economically, nutritionally and the food security nexus. Their production and downstream industries can help grow the economy, reduce unemployment, crime and poverty. Of particular interest to the economy is the expansion of all year round baby brassicas for export in order to earn the much needed foreign currency. Their increased production will be enabled as the country strives firstly to achieve Vision 2022 then the SDGs pertaining to food security, human health and the environmental health of planet earth. The fast growing leafy brassicas such as *Brassica juncea*, *Brassica napus* and or kale can be used as climate smart vegetables.

#### COMPETING INTERESTS

Authors have declared that no competing interests exist.

#### REFERENCES

1. Yamaguchi M. World vegetables. AVI, Westport, Connecticut, USA; 1983.
2. Wein HC. Lettuce. In: Wein (Ed). The Physiology of Vegetable Crops. Waalingford, Oxfordshire, UK. 1997;479-509.
3. Rice RP, Rice LW, Tindall HD. Fruit and vegetable production in Africa. MacMillan Publishers Ltd. London and Basingstoke, UK; 1986
4. Peirce LC. Vegetables: Characteristics, production and marketing. John Wiley & Sons Inc. New York, NY, USA; 1987.
5. Purseglove JW. Tropical crops: Dicotyledons: Vol. 1 and 2 combined. Longman Group Limited, Essex, UK; 1984.
6. Norman JC. Tropical vegetable production. Arthur H. Stockwell Ltd. Elms Court, Ifracombe, Devon, UK; 1992.
7. Tindall HD. Vegetables in the tropics. MacMillan, Basingstoke, London, UK; 1983.
8. Gomez-Campo C. Morphology and morphotaxonomy of the tribe Brassiceae. In Tsunoda S. Hinata. K. Gomez-Campo, C. (Eds). Brassica Crops and Wild Allies, Biology and Breeding. Japan Scientific Press, Tokyo. 1980;3-31.
9. Grzywacz D, Roszbach A, Rauf A, Rusell DA, Srinivasan R, Shelton AM. Current control methods for diamondback moth and other brassica insect pests and the prospects for improved management with lepidopteran-resistant. Bt vegetable brassicas in Asia and Africa. Crop Protection. 2010;29:68-79.
10. World Bank. Institutions, governance and growth: Identifying constraints to growth in Swaziland. African poverty reduction and economic management. World Bank Report no: 81031-sz, Washington DC; 2011.
11. Mashinini MS, Dlamini SG, Dlamini DV. The effects of monetary policy on agricultural output in Eswatini. Int J Econ Financial Res. 2019;5(5):94-99.
12. Masarirambi MT, Oseni TO, Shongwe VD, Mhazo N. Physiological disorders of Brassicas/Cole crops found in Swaziland: A review. African J. Plant Sci. 2011;5(1):8-14.
13. Thompson CF. Swaziland Business Year Book Christina Forsyth Thompson, Mbabane, Swaziland; 2005.
14. Dlamini GM, Lupapa T. Swaziland: Country Report to the FAO International Technical Conference on Plant Genetic Resources. FAO, Rome, Italy; 1995.
15. The CAPM Project, Commercial Vegetable Production Guide. United States Agency for International Development (USAID)/Ministry of Agriculture and

- Cooperatives, Mbabane, Swaziland. 1996;7:1-127.
16. Wang Cl. Leafy floral and succulent vegetables. In: Bartz JA, Brecht JK, (Eds.) Postharvest Physiology and Pathology of Vegetables. Second Edition, Revised and Expanded. Marcel Dekker, Inc, New York, NY 10016. 2003;599-623.
  17. Brecht JK. Underground storage organs. In: Bartz JA, Brecht JK, (Eds.) Postharvest Physiology and Pathology of Vegetables. Second Edition, Revised and Expanded. Marcel Dekker, Inc, New York, NY 10016. 2003;625-647.
  18. Earnshaw DM, Masarirambi MT, Dlamini BE, Nxumalo KA. Management of postharvest diseases of vegetables. Current J Applied Sci Technology. 2019;38(6):1-13.
  19. Coates L, Johnson G. Post-harvest diseases of fruit and vegetables. In: Brown J Ogle H (Eds) Plant Pathogens and Plant Diseases. 1997;533-548.
  20. Uzogara SG. The impact of genetic modification of human foods in the 21<sup>st</sup> century: A review. Biotechnol Advances. 2000;18:179-206.
  21. Masarirambi MT, Nxumalo KA, Earnshaw DM, Musi PJ, Dlamini BE. Genetic manipulation and product shelf life: Is there a connection? A developing world perspective. J Experimental Agric Int. 2019;42(2):1-7.
  22. Riggs TJ. Breeding F1 hybrid varieties in vegetables. In: Feistritz WP, Kelly AF, (Eds). Hybrid seed production of selected cereal oil and vegetable crops. FAO Plant Production and Protection Paper 82, Rome, Italy. 1987;149-173.
  23. Takahashi O. Utilization and seed production of hybrid vegetable varieties. In: Feistritz WP, Kelly AF, (Eds). Hybrid seed production of selected cereal, oil and vegetable crops. FAO Plant Production and Protection Paper 82, Rome, Italy. 1987;313-328.
  24. Oxford Dictionary, Oxford Advanced Learners' Dictionary. Oxford University Press, Oxford, UK; 2005.
  25. Xaba GB, Masuku MB. Factors affecting the choice of marketing channel by vegetable farmers in Swaziland. Sustainable Agric Res. 2013;1(2):212-220.
  26. Rugube LM, Nsiband SP, Masarirambi MT, Musi PJ. Factors affecting profitability of smallholder vegetable farmers in the Shiselweni region, Kingdom of Eswatini (Swaziland). Sustainable Agric Res. 2019;8(1):104-115.
  27. Musi PJ, Mdluli BS, Masarirambi MT. Agribusiness opportunities, constraints and challenges facing the youth in Swaziland. American Eurasian J Agric Environ Sci. 2018;18(1):50-56.
  28. Simelane SM, Terblanche SE, Masarirambi MT. Collective action for access to inputs, finance, markets and extension for smallholder farmers in Eswatini. South African J. Agric Extension. 2019;47(1):1-19.
  29. NAMBoard. National Agriculture Marketing Authority Annual Report, Manzini, Eswatini; 2019.
  30. Sanlier N, Guler, Saban N. The benefits of Brassica vegetables on human health. J. Human Health. Res. 2018;1:104.
  31. Orsini F, Remi K, Nono-Womdim R, Gianquinto G. Urban agriculture in the developing world: A review. Agronomy for Sustainable Development, Springer Verlag/EDP Sciences/INRA. 2013;33(4): 695-720.
  32. Kairiza T, Kembo GD. Coping with food and nutrition insecurity in Zimbabwe: Does household head gender matter? Agric Food Econ. 2019;7:24. DOI:<https://doi.org/10.1186/s40100-019-0144-6>
  33. Chinese Community Health Resource Centre. Heartburn, Gastrointestinal Reflux Disease (GERD), and Peptic Ulcer. Chinese Community Health Resource Centre, San Francisco, California, USA; 2018.
  34. Oguwike FN, Offor CC, Nwadihoha AN, Ebede SO. Evaluation of efficacy of cabbage juice (*Brassica oleracea* Linne) as potential antiulcer agent and its effect on the haemostatic mechanism of male albino Wistar rats. IOSR J Dental Med Sci. 2014;13(1):92-97.
  35. World Health Organization 'Children under-five stunted (%) , 2000–2008', 7 January 2010. Geneva, Switzerland: World Health Organization; 2010.
  36. Polla CM, Daly AM, Binns CW. Consumer perceptions of fruit and vegetables serving sizes. Public Health Nut. 2009;2(5):37-643.
  37. Rekhy R, Khan A, Eason J, Mactavish-West, Lister C, Mcconchie R. Australian consumer awareness of health benefits associated with vegetable consumption. J Dieticians Australia. 2016;74(2):175-184.

38. FAO/WHO. Fruit and vegetables for health. Report of a Joint FAO/WHO Workshop 1-3 September, Kobe, Japan; 2004.
39. Francis JA. Role of national universities in Africa's socio-economic transformation: Towards greater accountability, efficiency and effectiveness. The 15<sup>th</sup> RUFORUM Annual General Meeting, 2-6 December 2019, University of Cape Coast, Ghana; 2020.
40. Glanz K, Hersey J, Cates S, Muth M, Creel D, Nicholls J, Fulgoni 3<sup>rd</sup> V, Zaripheh S. Effect of a nutrient rich foods consumer education program: Results from the nutrition advice study. *J Acad Nutr Diet.* 2012;112(1):56-63.
41. Bazzano LA. The high cost of not consuming fruits and vegetables. *J Am Diet Assoc.* 2006;106:1364–1368.
42. The World Food Summit FAO, Rome, Italy; 1996.
43. FAO. Climate change and food security: A framework document. Rome, Italy; 2008.
44. Ojiewo C, Keatinge DJDH, Hughes J, Tenkouano A, Nair, RVarshney R, Siambi ME, Monyo E., Ganga-Rao NVPR, Silim S. The role of vegetables and legumes in assuring food, nutrition, and income security for vulnerable groups in Sub-Saharan Africa. *World Med. Health Policy.* 2015;7(3):187-210.
45. Sheahan M, Barrett CB. Review: Food loss and waste in Sub-Saharan Africa. *Food Policy.* 2017;70:1-12.
46. Havas K, Salman M. Food security: Its components and challenges. *Int. J. Food Safety, Nutrition and Public Health.* 2011;4(1):4–11.
47. Food Security. IFPRI: International Food Policy Research Institute; 2019. Available:www.ifpri.org/topic/food-security (Accessed 21/08/2019)
48. FAO. Support to country-level learning from actions for food security in Southern Africa. Available:http://www.fao.org/in-action/support-country-level-food-security-sadc/en/
49. Gundersen C, Zalik PJ. Food insecurity research in the United States: Where we have been and where we need to go. *Applied Econ Perspectives Policy.* 2018;40(1):119–135. Available:https://doi.org/10.1093/aep/pxx058
50. Dill A. Teaching nutrition through family and consumer sciences: A curriculum guide for middle schools. Wisconsin Department of Public Instruction, Madison, Wisconsin, USA; 2013.

© 2020 Masarirambi et al.; This is an Open Access article distributed under the terms of the Creative Commons Attribution License (<http://creativecommons.org/licenses/by/4.0>), which permits unrestricted use, distribution, and reproduction in any medium, provided the original work is properly cited.

*Peer-review history:*  
*The peer review history for this paper can be accessed here:*  
<http://www.sdiarticle4.com/review-history/57651>