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Full Length Research Paper

Nutritional assessment of a traditional local vegetable (*Brassica oleracea var. acephala)*

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The leaf cabbage (*Brassica oleracea var. acephala*), is a traditional local vegetable widely grown in rural and urban areas and consumed mostly by the poor in southern and eastern Africa. It is easy to propagate and is highly productive throughout the year. Three lines of leaf cabbage were evaluated for their nutritional value against a commonly grown exotic vegetable, Swiss chard (*Beta vulgaris* var. *cicla*). Swiss chard was superior to the leaf cabbage lines in protein, total ash, vitamin A, sodium and iron content. On the other hand, the leaf cabbage lines had significantly higher quantities of fibre, carbohydrate, fat, calcium, vitamin C and energy than Swiss chard. The leaf cabbage types tested have many good nutritional attributes that justify their genetic improvement through breeding in aspects such as protein, vitamin A and iron content.

Key words: *Brassica oleracea*, nutritional assessment, Swiss chard, traditional vegetable.

INTRODUCTION

Indigenous leafy vegetables play an important role in the tradition and food culture of African households and some are also used for medicinal purposes (Eifediyi et al., 2008). Traditional vegetables offer variety in family diets and help to ensure household food security (Luchen and Mingochi, 1995). Indigenous leafy vegetables are known as sources of many nutrients, vitamins, antioxidants, minerals and important proteins (Akula et al., 2007). The most commonly consumed exotic leaf vegetables in southern Africa include various types of kale (for example, Rape and Choumollier) and Swiss chard (*Beta vulgaris var. cicla*), which is often wrongly referred to as spinach (*Spinacia oleracea*), and various types of Cabbage (*Brassica oleracea var. capitata*). There is also one traditional vegetable: *Brassica oleraceae var*. *acephala* (leaf cabbage) that is now widely grown on both commercial and household scales in the southern African sub-region. This kale has several local names, for example, ‘Rugare’(comfort) or Covo in Zimbabwe, ‘muRhodesia’ in northern part of South Africa and ‘Sukuma wiki’(push out the week) in eastern Africa. The Vavhenda farmers of Limpopo province refer to *B. oleracea* var. acephala as ‘muRhodesia’ implying that the lines of the vegetable found in their area were introduced from Zimbabwe (previously Rhodesia). *B. oleracea var.* acephala is also called ‘walking stick cabbage’ due to the tall woody stalk it produces as it grows upwards for many months.

The vegetatively propagated types of leaf cabbage commonly grown in Zimbabwe were described by Mvere and van der Werff (2004) as Rugare and Viscose. Rugare is vegetatively propagated, rarely by seed except only at high altitudes, its plants are 2 to 3 m tall, offers repeated leaf pickings, has long life, has pale blue-green curly leaves but clones with different leaf colour exist. Viscose is a selection from Rugare which has improved hardiness in the field and segregates into different types, has darker green leaves and is more pronouncedly curled than Rugare. There are several clones in between

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Rugare and Viscose. Rugare leaves are consumed mostly as a relish taken in with stiff porridge made from maize (*Zea mays*) flour. It is considered to be delicious. Several methods are used to prepare the vegetable in southern Africa. The tender fresh leaves of this vegetable are sliced and commonly boiled for a short period (remaining green), salted and a little cooking oil is added. Rugare prepared in this manner can be consumed with beef stew, or other types of meat, together with either maize stiff porridge or rice. Rugare leaves can also be eaten with stiff porridge made from sorghum (*Sorghum bicolor*), pearl millet (*Pennisetum glaucum*), and cassava (*Manihot esculenta*) or even boiled potatoes (*Solanum tuberosum*). In East Africa, *B. oleracea var. acephala* can also be eaten together with “chapatti”. Where the vegetable serves as the sole relish, its taste is often enhanced by addition of tomatoes and onions, and sometimes pepper. Some people add animal fat chunks and boil these with the vegetable to add a meaty taste to the vegetable.

Another common way of preparing this vegetable is to add the vegetable to a pot with boiling meat and leave the vegetable to get cooked as the cooked meat is left to simmer. The sliced fresh leaves are sometimes boiled, salted and then a sauce made from smooth peanut butter is added. Cut leaves of ‘Rugare’ can also be salted and boiled briefly before they are sun-dried for later use in the dry season when availability of fresh vegetables becomes limited due to lack of irrigation water or when vegetable plant growth is adversely affected by high insect pest pressure during the summer months. Rugare is vegetatively propagated through plant apical cuttings or side suckers that develop from the leaf axil buds. These root readily as long as the soil is moist and the weather conditions are not very hot. The plant grows vigorously upwards for many months, and the leaves are plucked as it grows. With proper fertilization and watering, a plant can produce 3 to 4 harvestable leaves per week. As the plant reaches around 1.5 m height, growth vigour declines as seen in smaller leaves and longer frequency of harvest. At that stage, the plants can be re-established by planting apical cuttings and suckers. Most varieties of ‘Rugare’ continuously develop suckers from axil buds even after the leaf has been harvested and also many shoots at the base and lower nodes. These suckers need to be periodically removed, unless required for propagation, so that leaf growth is not slowed down.

If suckers are not disturbed, stem branches can be formed. Some growers leave some of the suckers to develop and these tend to keep the branched plants shorter with smaller leaves. Most vigorous growth is in the dry season as ‘Rugare’ suffers severe insect and disease damage in the rainy season. A wide range of varieties of ‘Rugare’ are grown. They differ in leaf structure and texture, duration to flowering and vigour of growth. The leaves differ considerably in taste and texture but most indigenes prefer ‘Rugare’ to Swiss chard or cabbage. Rugare is widely grown in Zimbabwe and in eastern Africa, in both rural and urban areas. It is the commonest vegetable in small backyard gardens, particularly in urban areas. The crop has recently been grown on a commercial scale in rural areas of Zimbabwe and peri-urban smallholdings in the northern part of South Africa. Foeken and Owuor (2008) reported that nearly every household of the low-income dwellers of Nakuru, Kenya, survived on *B. oleracea var. acephala*. The respondents in their survey commended the vegetable for its ease to grow and that it can sustain longer than other vegetable crops. Because recognition of traditional and indigenous vegetables is recent, very little research has been conducted on them. Whilst it is generally accepted that *B. oleracea* var. acephala is delicious and nutritious, the nutritional profiles of local lines are not known. A number of Rugare lines were therefore selected for evaluation of their nutritional status.

MATERIALS AND METHODS

Fully grown fresh leaves of three lines of ‘Rugare’, differentiated on the basis of leaf characteristics, were plucked for laboratory analysis of nutritional value. For the purpose of this study, the three types were named (i) ‘purple petiole’, (ii) ‘viscose’ and (iii) ‘plain’. Swiss chard leaves were included as the standard. The leaves of viscose are dark green, have a curly surface and are soft; the petiole of purple petiole has a light purple tinge on the inside and the leaves are light green, smaller than those of Viscose and have a tough texture, while the leaves of the Plain type are green and soft. Both purple petiole and plain have leaves with smooth surfaces.

Nutritional analyses

Nutritional analysis of the three Rugare lines and Swiss chard was done at the Limpopo Agro-food Technology Station laboratory of the University of Limpopo, Mankweng. The fresh leaf samples were oven dried at 50℃ overnight. They were ground to pass through a 40-mesh sieve and stored in air-tight containers under refrigerated temperature for further use. Moisture, ash, crude protein, fat and dietary fibre were analyzed by the methods described in AOAC (1990). All the analyses were carried out on dry weight basis and expressed per 100 g of edible portion. Moisture content was determined using the drying oven method, by drying a representative 5 g sample in an oven at 105℃ for 2 h. Ash content was determined by the incineration of a sample (4 g) in a muffle furnace at 600℃ for 6 h until the ash turned white. Crude protein was estimated by the Kjeldahl method. Total protein was calculated by multiplying the evaluated nitrogen percentage by 6.25. Fat was determined by petroleum ether extraction in a Soxhlet apparatus. Dietary fibre was analyzed by an enzymatic gravimetric method using the Tecator Fibertec E System.

Carbohydrates (g/100 g) were estimated by using a difference method described by FAO (1985), by subtracting the sum of the percentage of protein, moisture, fat and ash from 100. Mineral content (calcium, iron, sodium and potassium) was determined in the samples that were digested in a microwave digester. Two replicates of each sample (approximately 0.5 g) from each of the homogenized plant specimens were weighed into Teflon vessels after which 3 ml concentrated nitric acid and 1 ml concentrated hydrogen peroxide were added. Each vessel was closed with its Teflon lid. Vessels were positioned on the rotor and were secured by placing a circular safety band around them. The digested contents from the vessels were transferred into 50 ml flasks and the volume was made up using double deionized water. Concentrations were determined with an inductively coupled plasma (ICP) Perkin–Elmer spectrometer. Samples of respective mineral solutions were quantified against standard solutions of known concentration that were analyzed concurrently (Perkin–Elmer, 1996).

RESULTS

The nutritional profiles of the four vegetables analyzed are given in Tables 1 to 3. Nutritional composition of selected exotic leaf vegetables is given in Table 4. Comparison of the moisture content means at 95% confidence interval indicates that plain had more moisture ($p<0.05$) than Swiss chard and viscose but had similar values with purple petiole.

Swiss chard, viscose and purple petiole did not differ significantly in moisture content. Swiss chard had significantly higher protein ($P<0.001$) than the three strains of Rugare (Table 1). The Rugare lines did not differ in protein content varying from 20.7 to 21.8%. The leafy vegetables tested had carbohydrate (CHO) values ranging from 33.32 to 45.35%. Comparison of carbohydrate means at 95% confidence interval indicates that Swiss chard did not differ with plain but that the carbohydrate means of these two were significantly ($p<0.002$) lower than those of viscose and purple petiole. The carbohydrate contents of Viscose and Purple petiole were similar. Swiss chard attained the lowest fat content (2.41%) although this was not significantly ($p<0.05$) different from that of plain and viscose, but was significantly lower than that of purple petiole at 4.29% (Table 1). In terms of ash content, plain had the highest value of 19.24% while purple petiole had the lowest value of 12.66%. Swiss chard and plain had similar ash levels which were significantly ($p<0.001$) larger than those of viscose and purple petiole, which did not differ.

Mineral nutrient and vitamin content of the tested vegetable lines are given in Table 2. For potassium, plain type had 13.8% lower potassium than Swiss chard while purple petiole and viscose had 2.4 and 29.4% higher potassium than Swiss chard, respectively. Swiss chard had much less calcium than the Rugare lines (Table 2). Plain, viscose and purple petiole had 657.7, 364.1 and 638.5% more calcium than Swiss chard, respectively. Swiss chard had much more sodium than the three lines of Rugare. Swiss chard had the highest level of iron, which was significantly ($P<0.0001$) higher than in the three Rugare lines (Table 2). Purple petiole had the lowest level of iron, which was significantly lower than those of plain and viscose. Swiss chard had significantly ($P<0.0001$) higher levels of vitamin A than the two Rugare lines, namely, plain and purple petiole (Table 2). Purple petiole had the lowest vitamin A content, which was significantly lower than that of plain. Plain and purple petiole had similar levels of vitamin C, which were significantly ($P<0.0001$) more than, the levels in Swiss chard (about four times) (Table 2). Viscose was not evaluated for vitamin content. Viscose and purple petiole had significantly more energy than Swiss chard while plain had similar levels of energy with Swiss chard (Table 3).

DISCUSSION

Access to adequate protein is key to good growth and sound health in humans. Protein is involved in body building. The three Rugare lines tested were significantly inferior to Swiss chard in protein content. This is an aspect of these vegetables that needs to be improved upon because most people in the developing world do not get adequate animal protein. Vegetable protein provides the bulk of their protein requirements and on the standpoint of human health; this is preferable to animal protein. All the three ‘Rugare’ lines had higher carbohydrate, fat and fibre content than Swiss chard and there was considerable variation in these three parameters among the Rugare lines. This suggests the potential for selecting superior lines on the basis of these nutrient attributes. The plain line had only 7.6% more carbohydrate than Swiss chard but the viscose and purple petiole types exceeded Swiss chard by higher values of 36.1 and 35.3%, respectively. These results suggest therefore that the Rugare lines can supply more energy than Swiss chard since carbohydrates are a source of energy for cells and tissues (Insel et al., 2004). The results show that the Rugare lines had 53.9 to 78% higher fat content than Swiss chard. The Plain type had 15.6% lower fat content than purple petiole, which had the highest fat content. Akula et al. (2007) also reported higher fat content in kale than in Swiss chard. Fats are important as they provide energy, carry fat-soluble vitamins (such as Vitamin A, D, E and K), and also provide the cholesterol, which is the starting material for making hormones (Insel et al., 2004).

All the three Rugare lines had higher fibre content than Swiss chard and there were considerable differences among the Rugare lines. Plain type had 64.1% higher fibre content than the viscose type while the latter only had 16.6% higher fibre than Swiss chard. The results from this study generally agree with the study by Akula et al. (2007), who reported kale to have higher fibre content than several exotic vegetables. This is an important attribute of the Rugare lines. Fibre has various benefits, which include positive impact on weight control, improvement of glucose tolerance by delaying the

Table 1. Proximate analysis of three varieties of Rugare and Swiss chard on a dry weight basis.

Vegetable type	Moisture content%	Protein%	CHO%	Fat%	Fibre%	Ash%
Swiss chard	8.21^a(0.02)	32.25^b(1.36)	33.32^a(2.19)	2.41^a(0.37)	6.16^a(0.12)	17.62^b(0.31)
Plain	8.67^b(0.03)	20.71^a(0.10)	35.86^a(0.05)	3.71^{ab}(0.40)	11.78^d(0.06)	19.24^b(0.36)
Viscose	8.37^{ab}(0.10)	21.76^a(0.26)	45.35^b(1.28)	3.89^{ab}(0.52)	7.18^b(0.23)	13.44^a(0.62)
Purple petiole	8.47^{ab}(0.09)	21.25^a(0.47)	45.08^b(1.42)	4.29^b(0.39)	8.24^c(0.32)	12.65^a(0.78)
P value	0.016*	0.000***	0.002**	0.043*	0.000***	0.001**
$LSD_{(0.05)}$	0.32	3.31	6.28	1.84	0.91	2.39
CV%	0.89	3.21	3.66	11.92	2.53	3.53

*, ** and *** = significantly different *at P< 0.05, 0.01* and *0.001,* respectively. CHO = carbohydrate; CV = coefficient of variation; Means are followed by standard deviation in brackets; Means in the same column, with same letters are not significantly different at 5% level of significance.

Table 2. Mineral nutrient and vitamin content in leaves of three lines of 'Rugare' and Swiss chard on a dry weight basis.

Vegetable type	Potassium %	Mineral nutrient			Vitamins	
		Calcium %	Sodium mg/kg	Iron mg/kg	Vit. A mg/100 g	Vit. C mg/100 g
Swiss chard	2.96^a0.09)	0.78^a(0.01)	42977.5^c(3.53)	288.4^c(3.61)	2220^c(5.65)	57.9^a(3.11)
Plain	2.55^a(0.21)	5.91^b (0.03)	1313.5^b(16.26)	180.9^b(4.04)	251.0^b(2.82)	218.2^b(5.80)
Viscose	3.83^a(0.05)	3.62^b(0.21)	1327.5^b(7.43)	178.5^b(0.89)	-	-
Purple petiole	3.03^a(0.68)	5.76^b(0.09)	1154.5^b(7.77)	161.6^a(1.14)	161.5^a(12.02)	234.2^b(7.92)
P value	0.095^{ns}	0.000***	0.000***	0.000***	0.000***	0.000***
$LSD_{(0.05)}$	1.56	0.49	43.03	12.04	33.74	18.16
CV%	11.75	2.82	0.86	1.38	0.89	2.48

*, ** and *** = significantly different at *P<0.05, 0.01* and *0.001*, respectively; CV = coefficient of variation; Means are followed by standard deviation in brackets; Means in the same column, with same letters are not significantly different at 5% level of significance.

Table 3. Energy content in Swiss chard and three leaf cabbage lines.

Vegetable	Energy kJ/100 g	Energy kcal/100 g
Swiss chard	1174.7^a(19.08)	280.76^a(4.62)
Plain	1094.97^a(42.95)	261.71^a(6.61)
Viscose	1281.35^b(19.92)	306.25^b(4.60)
Purple petiole	1284.95^b(17.09)	307.11^b(4.09)
P value	0.002**	0.002**
$LSD_{(0.05)}$	91.22	21.82
CV%	1.75	1.75

*, ** and *** = significantly different at *P<0.05, 0.01* and *0.001,* respectively; CV = coefficient of variation; Means in the same column, are followed by standard deviation in brackets; Means with same letters are not significantly different at 5% level of significance.

movement of carbohydrates into the small intestine, removal of cholesterol and promotion of regularity of defaecating (Insel et al., 2004). Only the plain type of Rugare had higher ash% than Swiss chard in the present study. All the four vegetables evaluated had comparable energy values ranging from 10950 kJ/kg for plain to 12850 kJ/kg for purple petiole. Purple petiole and viscose had significantly higher energy than Swiss chard. The energy profiles of these vegetables were consistent with their carbohydrate content. Vitamins play a vital role in the extraction of energy from carbohydrates, fat and protein. Swiss chard had much higher vitamin A than the Rugare lines. The results of this study thus suggest a need for breeding to improve vitamin A content as it is very important nutritionally. Vitamin A, which is fat-soluble, is critical for vision, for maintaining healthy cells, particularly skin cells, for fighting infections and bolstering immune function, and promoting growth and development (Insel et al., 2004). Vitamin A's influence in bolstering the immune system is very important in the present day when many poor people are challenged by viral infections.

The two Rugare lines tested had significantly higher levels of vitamin C than Swiss chard. This is a positive attribute of these traditional vegetables as vitamin C promotes good health. Vitamin C, which is water-soluble, has many benefits to the human body. It is an antioxidant, which minimizes free radical damage in cells and enhances the absorption of nonheme iron, which comes mainly from plant foods. It has been linked with

Table 4. Nutritional composition of exotic leaf vegetables per 100 g fresh weight.

Vegetable	Energy (kcal)	Moisture (g)	Protein (g)	Fat (g)	Fibre (g)
Spinach	26	91	3.2	0.3	4.3
Cabbage	24	92	1.3	0.2	5.4
Lettuce	18	94	1.3	0.3	3.5
Swiss chard	25	91	2.4	0.3	4.6
Cauliflower	27	97	2.7	0.2	5.2
Kale	53	83	6.0	0.8	9.0

Source: Akula et al. (2007).

reduction of risk of chronic diseases such as heart disease, certain forms of cancer and cataracts, and is essential to the activity of many enzymes (Insel et al., 2004). Vitamin C also helps to protect the body against cancer and other degenerative diseases like arthritis and Type 1 diabetes mellitus (Eifediyi et al., 2008). All the three Rugare lines were superior to Swiss chard regarding calcium content. This is important because some of the poor people may not readily access other foods providing calcium such as milk, yoghurt and cheese. Hence adequate consumption of these vegetables may meaningfully contribute to their body requirements for calcium. Mineral calcium is required for strong bones, teeth, hair, nails and plays an important role in muscle contractions and relaxation, blood clotting, synoptic transmission and many cellular functions, such as production of energy and the maintenance of the immune function (Clicks, 2007). Swiss chard had comparable levels of potassium to that of the three Rugare lines. Potassium and magnesium are responsible for reducing blood pressure (Eifediyi et al., 2008).

Swiss chard was superior to the Rugare lines in terms of iron content. This perhaps is another characteristic that needs improvement in the Rugare lines as iron is important in the body. Iron is needed for haemoglobin formation. Vegetables with significant amounts of iron are recommended for patients suffering from anaemic convalescence. Iron in leaf cabbage is available in an easily digestible form (Mvere and van der Werff, 2004). Swiss chard was much more superior to Rugare lines in terms of sodium content but this is not critical since most diets provide adequate salt intake and sodium in the salt form is associated with high blood pressure if taken in large amounts. Only plain had higher ash content than Swiss chard while viscose and purple petiole had significantly lower ash content than Swiss chard. This implies that the latter two have considerably less inorganic minerals than Swiss chard, which is an aspect that could be improved through breeding. The nutritional value of Brassica vegetables has medicinal implications. Leaf cabbage contains high levels of glucosinolates, which form compounds with antioxidant and anticancer activities during preparation (Mvere and van der Werff, 2004). Mvere and van der Werff (2004) provided United States Department of Agriculture (USDA) data on nutritional composition of leaf cabbage per 100 g of raw leaf as: water 84.5 g, energy 209 kJ (50 kcal), protein 3.3 g, fat 0.7 g, carbohydrate 10.0 g, total dietary fibre 2.0 g, Ca 135 mg, P 56 mg, Fe 1.7 mg, Mg 34 mg, Zn 0.44 mg, vitamin A 15,376 IU, thiamin 0.11 mg, riboflavin 0.13 mg, niacin 1.0 mg, folate 29 ug and ascorbic acid 120 mg.

This nutritional profile suggests need for a more complete analysis of these Rugare lines for effective selection on nutritional attributes. Brassica vegetables are highly regarded for their nutritional value as they provide high amounts of vitamin C and soluble fibre and also contain multiple nutrients with potent anti-cancer properties. It has been recently discovered that 3, 3'-Diindolylmethane in Brassica vegetables is a potent modulator of the innate immune response system with potent anti-viral, anti-bacterial and anti-cancer activity (Wikipedia, 2009). The findings from this study generally show that Rugare, a traditional vegetable, has comparable nutritional value to commonly used exotic vegetables such as Swiss chard, spinach, lettuce and cabbage. Afoloyan and Jimoh (2008) and Kala et al. (2008) reported a similar situation for indigenous leafy vegetables.

The nutritional (and medicinal) attributes of Rugare and its wide adoption in Eastern and Southern Africa warrants that researchers, particularly plant breeders, should pay more attention to this vegetable. They could help develop or identify a few cultivars of known nutritional profiles, having improved some of the existing lines on identified nutritional deficiencies. The need for more breeding and research work on cultural practices was also stressed by Mvere and van der Werff (2004). Foeken and Awuor (2008) cite many reports that indicate the importance of urban agriculture to the poor as it contributes to household food and nutritional security. Cultivation of Rugare does not require large pieces of land as it is highly productive. It is thus well suited to urban areas where residents in high density surbubs only have small pieces of their yards for gardening. Improvement in the nutritional value of lines of *B. oleracea var. acephala* can go a long way in improving the nutrition and health of the poor in southern and eastern Africa.

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