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Food Processing and Preparation Technologies for Sustainable Utilization of African Indigenous Vegetables for Nutrition Security and Wealth Creation in Kenya

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ABSTRACT

The purpose of traditional food processing is preservation to maintain a supply of wholesome, nutritious food during the year and preservation for the time of scarcity. While food processing still has the main objective of providing a safe nutritious diet in order to maintain health, other aspects, particularly the generation of wealth for the producer and seller, have become increasingly important. While most people in the rural areas still rely on traditional foods for their basic diet, those in urban and cosmopolitan centers tend to purchase processed and packaged foods for convenience. The increasing number of women who now work away from home adds additional pressure for such changes. Even people with a heavily traditional diet are demanding external products either as occasional treats such as gassy drinks, or basic commodities such as white sugar and flour. Although over 60% of the Kenyan populace lives below the poverty line resulting in malnutrition, poor health and inadequate basic necessities, Kenya is endowed with agro-biodiversity such as African Indigenous Vegetables (AIVs) that are highly nutritious, have health benefits, income generation potential and agronomic advantages that need exploiting. Research carried out at Maseno University in 2008 had the aim of developing East African indigenous vegetable recipes in order to promote utilization of AIVs for micronutrient malnutrition alleviation. East African indigenous vegetable products were developed which could contribute to poverty reduction and ensure availability of these vegetables during off-seasons even in supermarkets in Kenya. This technology should be further developed and disseminated to the community to address food insecurity.

INTRODUCTION

The most serious threat to the survival of humanity is the ever-increasing gap between population growth and food supply (Yadav & Sehgal, 2004). Changing customs have lead to the increasing use of convenience foods at home and in food outlets. Mild or minimal processing and preservation treatments lead to high convenience and nutritional value which is advantageous to consumers and food services (Wiley, 1994). However, preservation of agricultural produce is one of the central problems facing developing countries. Owing to the lack of and/or inadequacy of preservation methods, large quantities of urgently needed food spoil there. As time goes on, these problems will be aggravated by the growing dietary needs of growing populations in these countries. In Africa and Kenya in particular, this problem exists with many fruit and vegetable varieties (especially the indigenous ones) resulting in wastage during the in-season and limited supply during the off-season accompanied by high prices (Habwe, 2008; Abukutsa-Onyango, *et al.,* 2006) because most locally available vegetables are seasonal and not available year-long (Chavasit *et al.*, 2002). African indigenous vegetables cannot be marketed fast enough when they are in-season owing to their limited keepability (perishability). Appropriate preservation and storage methods should be performed in order to prolong the consumption of such nutrient-rich foods all year round (Chavasit *et al.,* 2002).

This chapter presents empirical results from a study that sought to develop affordable appropriate food processing and preparation technologies for sustainable utilization of African indigenous vegetables for nutrition security and wealth creation in Kenya. The study also sought to process

African indigenous vegetables by blanching and freeze-drying and to extend the shelf life of the processed African indigenous vegetables through product development using simsim *(Sesamum orientale L.)*.

African Indigenous Vegetables (AIVs)

Indigenous vegetables are those vegetables whose natural home is in a specified region (Maundu, 1997). There are more than 45,000 species of plants in sub-Saharan Africa of which about 1000 can be eaten as green leafy vegetables which happen to be the mainstay of traditional African diets (MacCalla, 1994). *Indigenous* and *traditional* are words used here to describe leafy vegetables that have been part of the food systems in sub-Saharan Africa for generations. Indigenous leafy vegetables are those that have their natural habitat in sub-Saharan Africa while the traditional leafy vegetables were introduced over a century ago and due to long use, have become part of the food culture in the sub-continent (Smith & Eyzaguirre, 2007). Examples of AIVs found across Eastern Africa include African nightshade (*Solanum scabrum*), spider plant (*Cleome gynandra*), vegetable amaranth (*Amaranthus hybridus*), slenderleaf (*Crotalaria brevidens*), jute mallow (*Corchorus olitorius*), vegetable cowpea (*Vigna unguiculata*) pumpkin leaves (*Curcurbita muschata*) and African kale (*Brassica carinata*) among many others (Abukutsa-Onyango *et al.*, 2006).

Immense attention has been directed to fruits and vegetables due to the increased awareness of the health protecting properties of non-nutrient bioactive compounds found in them, making them vital components of daily diets. They also contain non-nutrient bioactive phytochemicals that have been linked to protection against cardiovascular and other degenerative diseases (Smith & Eyzaguirre, 2007). AIVs play a key role in income generation and subsistence (Adebooye & Opadode, 2004). They are inexpensive, easily accessible and provide millions of African consumers with health-promoting compounds such as vitamins, minerals, anti-oxidants and even anti-cancer factors needed to maintain health and fight off infections (MacCalla, 1994; Abukutsa-Onyango, 2003; and ICRAF, 2004). Studies have also shown that countries that retain indigenous vegetable diets and have high consumption of these vegetables are much less likely to be affected by cardiovascular diseases, diabetes and other adverse consequences of nutrition in transition (Johns & Sthapit, 2004). They are compatible in use with starchy staples and represent a cheap but quality nutrition to the poor both in urban and rural areas where malnutrition is widespread (Maundu, 1997).

AIVs could make a positive contribution to world food production because they adapt easily to harsh or difficult environments, the input required for growing them is lower compared with other crops, and they are highly resistant to pathogens thus requiring fewer chemicals and pesticides (Abukutsa-Onyango *et al*., 2006). This makes them suitable and advantageous for people living in areas with high population density like Africa. AIVs can act as a substitute for other cultivated crops to alleviate nutrient deficiencies by increasing nutrient supplies (Engle & Altoveras, 2000). They are inexpensive and easy to cook (Yadav & Sehgal, 2004) and their production can compensate for low vegetable supply during the off-season, potentially helping to alleviate nutrition deficiency during this period (Engle & Altoveras, 2000).

African indigenous leafy vegetables have long been known and reported to have health protecting properties and uses. They are increasingly recognized as possible contributors of both micronutrients and bioactive compounds to the diets of populations in Africa (Smith & Eyzaguirre, 2007). They are a valuable source of nutrition in rural areas and they contribute substantially to protein, mineral and vitamin intake together with fibre; they also add diversity to the diet. AIVs should therefore be included in the diet to overcome various nutritional problems like iron and vitamin A deficiency (Midmore *et al*., 1991; Maundu, 1997; Kawatra *et al*., 2001; Yadav & Sehgal, 2004; Oniang'o *et al.,* 2005). The minerals and vitamins found in AIVs exceed the levels found in exotic vegetables like cabbage; they are also compatible to use with starchy staples because they contain ascorbic acid, which enhance iron absorption (ICRAF, 2004). Table 1 gives the nutrient content of raw AIVs.

Consumption of African Indigenous Vegetables

The International Plant Genetic Resource Institute (IPGRI - now Bioversity) has been involved with the promotion of African Leafy Vegetables (ALVs) in sub-Saharan Africa (SSA) since 1995 (IPGRI, 2004). Much attention has been centered on the exploitation and utilization of unusual plant materials for food. However, much of the attention has been paid to seeds while green leafy vegetable sources have, to a large extent, been ignored (Yadav & Sehgal, 2004). This ignorance is to a larger extent due to populations of Africa having negative perceptions of ALVs and this has led to low levels of consumption, causing poor nutrition status (Obel-Lawson, 2006). IPGRI, in partnership with the Dutch government, has led a campaign to try and reverse the decline in the use of ALVs (Shiundu & Oniang'o, 2007). Per capita consumption of fruits and vegetables in sub-Saharan Africa lags behind that of the other regions, showing an overall decline between 1986 and 1995 (Shiundu and Oniang'o, 2007). While *per capita* apparent consumption of vegetables in developing countries went from 68.7 kg *per capita* in 1986 to 75.3 kg in 1995 on average (a 0.92% increase), sub-Saharan Africa showed a 0.19% decline and remained as low as 29 kg of vegetables *per capita* consumption on average (Segre *et al*., 1998, as cited by Shiundu & Oniang'o, 2007).

Table 1: Nutrient Content (mg/100 g) of Raw AIVs from East Africa

AIV	Ca	P	Fe	Mg	Na	K	Vit C
Amaranth	323.7	89	7.5	122	230	341	50
Nightshade	100.47	62.50	8.63	461	74.22	100	54
Slenderleaf	1,234.4	11.25	28.13	155	22.66	162.50	
Cowpea	428.01	17.23	9.62	46.73	31.25	81.25	8
Pumpkin leaves	231.5	155	1.026	46.45	20.31	125	80
Cassava leaves	300	120	7.7	6	605	-	8
Sweet potato leaves	117.80	30	19.35	61.35	40	620	70
Spider plant leaves	1,484.4	48.95	29.67	47.50	18.75	75	
Tomatoes	14.06	19.04	1.997	11.86	45.193	47.83	10
Onions	39.81	39.54	1.29	18.5	5.32	158.67	11
Simsim	1,429.47	817.5	9.7	459.5	4.21	299	0

Source: Sehmi (1993).

It is ironic that as Africa grapples with malnutrition, the continent is endowed with a high diversity of under-utilized fruits and vegetables that are rich in micronutrients (Oniang'o *et al*., 2005). It is in this regard that beginning in 2001, IPGRI – with support from the International Development Research Centre of Canada - spearheaded a major public awareness campaign including training of farmers to grow leafy vegetables in hygienic conditions; it has also worked with a marketing expert in Kenya to attract new customers for ALVs. A local NGO, Family Concern, distributes the farmers' produce to Kenya's largest supermarket chain (Oniang'o *et al*., 2005). Very little is known about the production and consumption pattern of ALVs in sub-Saharan Africa (Smith & Eyzaguirre, 2007). However, evidence is emerging that ALVs are now a much sought-after item on the menus of back-street eating venues, in five-star hotels and are even served in Parliament (Shiundu & Oniang'o, 2007).

Processing of African Indigenous Vegetables

Large quantities of AIVs spoil due to insufficient processing capacity and growing market difficulties caused by intensifying competition from exotic vegetables (Schippers, 2002). There had been no sustainable production of the vegetables due to neglect and lack of appropriate production technologies, leading to low production and poor distribution of indigenous vegetables in Kenya (MOA, 1999). Drying has been an African way of processing leafy vegetables to make them available during periods of short supply. Although drying is one solution to the problem of perishability, it does not satisfy the needs of a large population of consumers, particularly urban dwellers (Smith &

Eyzaguirre, 2007). Developing vegetable products with extended shelf life can help solve these problems, while also making an important contribution to improving the population's income and supply situation (Habwe, 2008). Traditional sun drying methods often yield poor quality, since vegetables are not protected against dust, rain and wind, or even against insects, birds, rodents and domestic animals while being dried. Soil contamination with microorganisms, formation of mycotoxins and infection with disease-causing microorganisms are the result. The drying equipment used in industrialized countries overcomes all of these problems, but unfortunately it is not very well-suited for use in Kenya because it requires substantial capital investment and a well-developed infrastructure. Solar drying or freeze drying and vegetable product development using simple techniques combine the advantages of traditional and industrial methods, namely low investment costs and high product quality.

In spite of the abundance of African indigenous and traditional leafy vegetables, they remain under-exploited and under-utilized due to various constraints, including processing, distribution and marketing, as well as nutrition information (Shiundu & Oniang'o, 2007). The easy perishability of African Leafy Vegetables poses major challenges with their distribution and marketing (Smith and Eyzaguirre, 2007). Because of the varied growing and harvesting seasons of different vegetables at different locations, the availability of fresh vegetables differs greatly in different parts of the world. Processing can transform vegetables from perishable produce into stable foods with long shelf lives and thereby aid in their global transportation and distribution (Anon., 2006). According to Smith & Eyzaguirre (2007) there is a need to develop and promote locally appropriate processing techniques to minimize post harvest losses and ensure regular supplies of African leafy vegetables from the production areas to consumers in peri-urban and urban centres. Based upon this realization, a study was carried out at Maseno University to develop East African indigenous vegetable recipes which resulted in development of vegetable products.

Methodology

A research study on recipe development of East African indigenous vegetables was carried out at Maseno University, which is located on the equator at an altitude of about 1500 meters above sea level. Long-term average rainfall in Maseno town is 2074 mm per annum and its distribution is bimodal with peaks in March/April and September/October (Oseko, 2007). Soils are mainly dominated by vertisols, with a fairly acidic pH in water of 4.5 to 6.5 (Otieno *et al*., 1993; Oseko, 2007). The soils are also deep, very deficient in P and N, and have a moderate P fixation (FAO, 1997 cited by Oseko, 2007). Mean annual day temperature is 20°C with the average maximum daily temperature not exceeding 31°C and the average minimum night temperature not dropping below 15°C (Otieno *et al*.., 1993; Oseko, 2007).

AIVs commonly found in East Africa, which were used in these experiments, were planted at the Maseno University Botanic garden and included: African nightshade (*Solanum scabrum)*, vegetable amaranth (*Amaranthus blitum)*, slender-leaf (*Crotalaria ochroleuca)*, and cowpea (*Vigna unguiculata)*. Land was prepared by ploughing and harrowing to a fine tilth. The plots of 5 by 5 meters were demarcated and poultry manure mixed with the soil in the demarcated soil at a rate of 5 tonnes per hectare. Seeds of each selected AIV were mixed with the soil at a rate of 1:10 and drilled in the respective plots at a spacing of 30 cm. After two weeks, thinning was done to leave an inter-row spacing of 15 cm for all. All other agronomic practices were done to ensure optimum growing conditions. Harvesting by uprooting of the various AIVs was done at four weeks after seedling emergency for recipe development and evaluation as shown in Figure 1. This was done to enable the researchers to have AIVs with the same harvest age in order to avoid other factors that may lead to nutrient loss in the AIVs, and also have uniform AIVs with similar environmental exposure in order to avoid bias during nutrient analysis. The indigenous vegetables were blanched using the procedure described below and then freeze-dried:

1. A large pan half-full of water was brought to boil until it was boiling rapidly.
2. The prepared vegetables were put into a wire basket and gently lowered into the boiling water.

3. When the water began to boil again, vegetables were left in for two minutes.
4. The basket with vegetables was then removed from the boiling water and plunged into ice-cold water to stop the cooking process.
   The blanched vegetables were then drained and packaged into polythene bags, labeled and then placed into the freezer to freeze dry.

After freeze-drying, vegetable products were developed following a standardized procedure as indicated in the flow chart below.

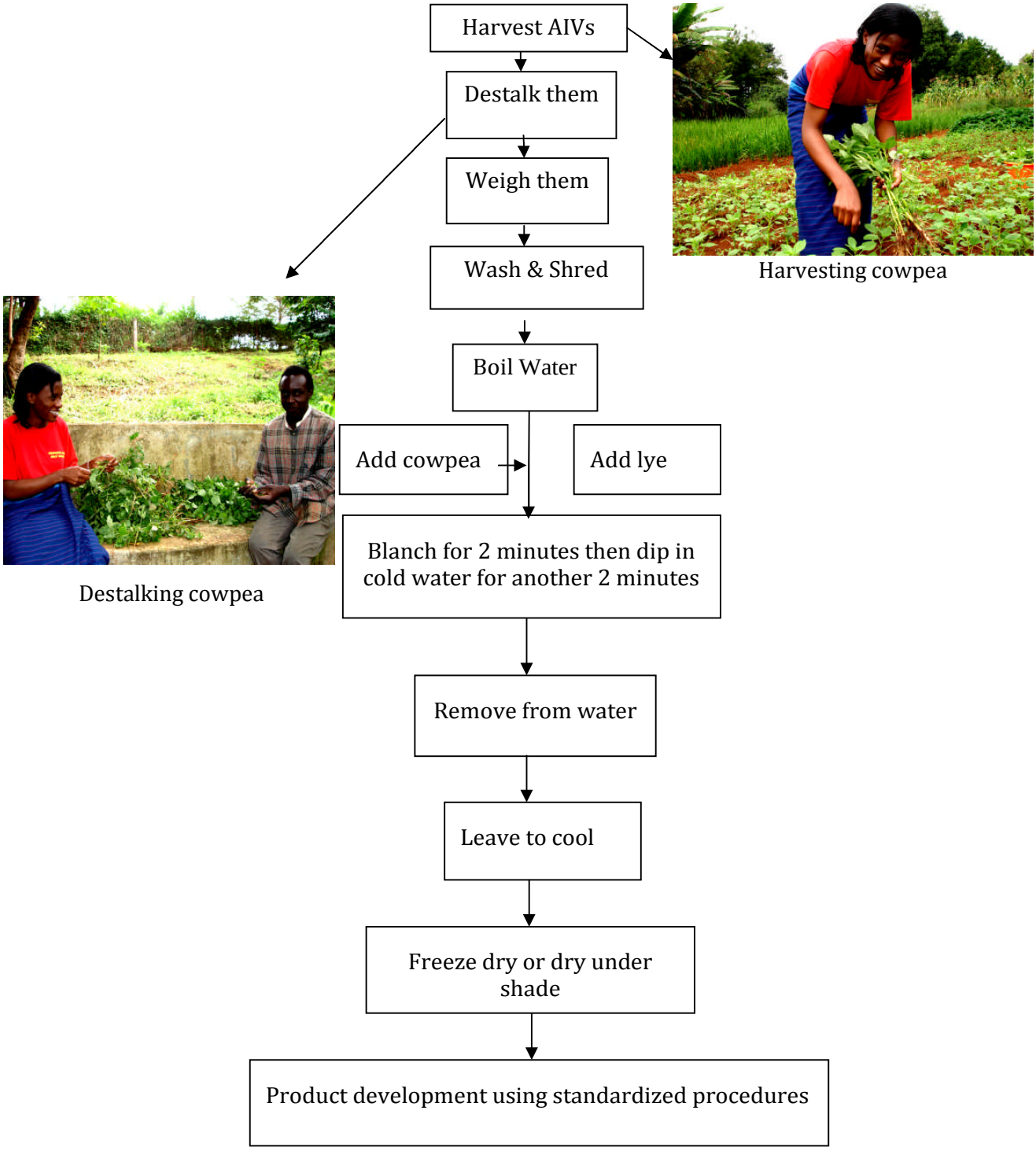

Figure 1. Simplified flow sheet for development of African Indigenous Vegetable products

RESULTS AND DISCUSSION

Products of various shapes and sizes were developed using the selected AIVs detailed above. Figure 2 shows some AIV products developed using appropriate and affordable technologies indicated in the methodology above.

Figure 2. AIV products developed using appropriate and affordable technologies
From left: Simshade (mixture of nightshade/simsim); Simco (simsim/cowpea ladule); and Simama (amaranth/simsim)

AIVs have long held a significant role as important components in African diets; they are indispensable ingredients in soups or sauces that accompany carbohydrates or staples (Smith & Eyzaguirre, 2007). To deviate from the norm, the developed vegetable products can be consumed as snacks or accompany a beverage thus broadening the consumption habits. AIVs are also seasonal. During the in-season a lot of vegetables go to waste because there are too many in the market; however, there is limited supply of these vegetables during the off-season thus leading to increased prices and reduced consumption. Therefore the development of African indigenous vegetable products could go a long way in minimizing wastage during the in-season and ensuring availability of vegetables during the off-season, hence resulting in year-round supply of this nutrient dense commodity.

Like the other agricultural activities in Africa and particularly Kenya, African indigenous vegetable farming relies mostly on rain-fed agriculture. This leads to fluctuating supply of vegetables on the markets because most small-scale farmers lack the means to transport their produce to far-distant and lucrative markets in the urban centers. Farmers are therefore open to exploitation by middlemen; this can be addressed through value-adding processes (Shiundu & Oniang'o, 2007). Value addition through product development will help address the issue of perishability and fluctuating supply of the vegetables on the market. In the long run this will help alleviate barriers to food security and income generation.

The poor state of infrastructure, particularly roads, that is found in most of the rural areas where African indigenous leafy vegetables are cultivated worsens during the rainy season. There is much wastage because of unavailability or limited means of transport to reach the markets at such time. Even those vegetables that manage to get to the markets are poor in quality due to delays and subsequent biological deterioration during transportation and distribution processes (Shiundu & Oniang'o, 2007). As well as helping curb the problem of perishability which demands that vegetables reach the markets quickly or on time, product development will also help minimize biological deterioration of vegetables which occurs during transportation and distribution.

There are possibilities to consider exporting the vegetables because the African or Kenyan diasporas would relish identifying themselves with these vegetables. Asian vegetables are a major component of Kenya's horticultural export industry, because of the people of Asian origin who reside in the United Kingdom and other parts of Europe (Shiundu & Oniang'o, 2007). Development of well-packaged vegetable products will enable the possibility of exporting African indigenous leafy vegetables to Africans, East Africans or Kenyans living abroad.

Implications for Research and Practice

Public education and promotion of African indigenous leafy vegetables needs to support the marketing component.

Farmers need to be trained in marketing and business skills through workshops and seminars to enable them to maximize output as well as income from their farms.

The future of African indigenous leafy vegetables is dependent on increased research on nutrition, processing and marketing.

It is not enough to encourage local farmers to grow their traditional crops without adequate markets. Successful marketing is important in the effort of creating sustainable livelihoods. This could be a major source of employment and add value to vegetable processing.

Traditional crops could be a major source of food in the diet, earn valuable foreign exchange by exporting, provide opportunities for import substitution, and generally benefit a large number of people.

There is need for research in the development of diversified recipes that are nutrient-dense and for alternative uses of these indigenous vegetables.

Some AIVs are believed to have medicinal value. This calls for further research to authenticate this claim and explore the possibility of pharmaceutical properties.

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