DOCUMENTATION OF INDIGENOUS TRADITIONAL KNOWLEDGE DETERMINING CULTIVATION AND UTILIZATION OF PUMPKINS IN KENYA

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ABSTRACT
Pumpkin (*Cucurbita moschata* (Lam.) Poir) is an emerging indigenous vegetable in Kenya. However, its potential remains unexploited. This study surveyed pumpkin germplasm in Kakamega and Nyeri to determine factors enhancing conservation, preservation and production among smallholder farmers. A survey done in 2012 collected 155 accessions, with 70 from Kakamega and 85 from Nyeri. Indigenous traditional knowledge (ITK) determining cultivation and utilization was gathered from growers. Results showed that pumpkins were intercropped in less than half a hectare by majority of the farmers (P=0.00). The pumpkins had significant (P=0.00) differences in usage, with 57% cultivated for food and income, 33% for only food, and 3% for medicinal values. Pumpkin fruits and leaves were significantly ((P=0.00) utilized by 38% households during drought. Variegated accessions were significantly (P=0.00) the most preferred. Cultural beliefs, folklores and ITK were used by the communities to safeguard production and conserve diversity. The pumpkins inherited were significantly (P=0.00) more than those borrowed or bought from markets within and beyond the survey area, introduced by NGOs, or from beyond Kenyan borders. Since then, retained seeds have significantly (P=0.00) been used as seed sources. Significantly (P=0.00) more farmers selected accessions for planting based on fruit and leaf quality. Storage form was mostly seed or whole fruits (P=0.00), with no use of special containers. Seed cleaning and packaging was not done. Seeds were packaged in plastic polybags and stored in family houses, without any protection against pests. Storage above fire was used by one farmer. There were significant differences (P=0.00) in constraints reported, although none of the constraints was major. Disease incidences and pests such as wasps, fruitflies and rodents were reported. Taxonomic identification classified the collected accessions in *Cucurbitaceae* family and *Cucurbita moschata* (Lam.) Poir species. No cultivar names were appended due to lack of descriptor tools. Accessions were grouped in two categories based on leaf, fruit and seed characters. Pumpkins have immense potential as sources of food and income, nutrition and health benefits for communities growing them. Interventions to strengthen and preserve the ITK should be adopted and promoted to ensure local pumpkins are available for reference and improvement in future.
Keywords: Accessions**,** Conservation, Indigenous, Pumpkin, Farmers, Storage, Selection

INTRODUCTION

Pumpkins are not highly regarded by smallholder farmers in Kenya. They are mostly cultivated to overcome undernourishment and food poverty (Ondigi *et al.*, 2008). Production of pumpkin and squash in Kenya from 2005 to 2007 was estimated to yield 15,728 MT from 927 ha (HCDA, 2008). World production in 2000 was estimated to be 16 million tones from1.3 million ha. African production was estimated to be 1.8 million tonnes from 140,000 ha, corresponding to an average yield of 12.8 t/ha (FAO, 2003). However, these data are incomplete and quite old. Besides, only limited information per species is available to date. The great diversity in pumpkin cultivars and landraces indicates an enormously untapped potential (Ondigi *et al.*, 2008).

Pumpkins grow well as intercrops and are less demanding in management since their short growing periods lend themselves favourably to mineral-nutrient intervention programmes (Onyango, 2003). They have also been reported to be pest and disease-tolerant (Muthoni *et al*., 2010). Small-scale farmers grow pumpkins for subsistence, using organic manure available on farms (Onyango, 2007; Echessa, 2011). They are widely grown for their leaves, fruits and seeds, and supply calcium, iron, vitamin A, oil (25 - 55%, rich in unsaturated oleic and linoleic acids), protein (25 - 35%) with high amounts of arginine, aspartate and glutamic acid, but are deficient in lysine and sulphur-containing amino acids (Ndoro *et al*., 2007).

The present study conducted local surveys to collect indigenous knowledge possessed by farmers on productivity and use of pumpkins. Enhanced knowledge plays pivotal role in food and nutrition security (Chweya, 1994; Schippers, 2000). The study collected information on pumpkin germplasm and from farmers on growth methods, conservation methods, production constraints and solutions. The present paper gives a synopsis of the methodology and subsequent findings.

MATERIALS AND METHODS

Local Survey

Diagnostic and formal surveys were conducted in Kakamega and Nyeri Regional Service Units (RSUs). The two regions have prime lands, covering a wide range of socioeconomic and natural conditions ideal for pumpkin production and agribusiness. The areas are similar in rainfall and population density. Rainfall is ample and accommodates two cropping seasons (Place *et al*., 2006). The survey was done for a single day in each subcounty on pumpkin. Pumpkin being an annual crop, the short visit did not miss the required ethnobotanic information.

Kakamega lies at 00° 16' N, 34° 45' E and 1585 m above sea level. The mean annual temperature is 20°C, rainfall is bimodal with a mean of 2012 mm, and soils are classified as *dystro-mollic* Nitisol (Jaetzold and Schmidt, 1983b). Nyeri lies at 36º - 38º E, 0º 38´ S, and 1810 m above sea level. Annual mean temperature is 19ºC. The area receives bi-modal rainfall with a mean of 1500 mm (Kassam *et. al.*, 1991). The soils are well-drained, extremely deep, dark-reddish brown to dark-brown, friable and slightly clay with acid humic top soil (andohumic Nitosols with umbric Andosols) (Jaetzold and Schmidt, 1983a). Participatory Rural Appraisal (PRA) techniques incorporated key informant interviews and checklists (Friss-Hansen and Bhuwon, 2000). International Plant Genetic Resources Institute (IPGRI, 2003) descriptors were used to obtain specific information on practices, problems, indigenous traditional knowledge (ITK), constraints and opportunities for production and utilization of pumpkins. This information helped tap indigenous knowledge (Engels *et al*., 1995), important in determining cultivation, conservation and constraints of growing pumpkins in Kenya.

Sampling Strategy and Techniques

Ten sub-counties of Kakamega and Nyeri were selected due to their abundance in terms of pumpkin germplasm and varied agro ecological zones. Initial information on pumpkin abundant sub counties was obtained from the former provincial director of agriculture (PDA) offices in both Regional Service Units (RSUs). A total of 76 key informant farmers were interviewed. The key informant farmers were known pumpkin farmers identified through purposive sampling based on their interest and the constraints that needed to be addressed. Checklists were used to hasten and facilitate discussions with key informants who were selected with the assistance of field extension officers (FEOs) in the ministry of agriculture. Purposive sampling was used with a focus of capturing maximum information on indigenous traditional knowledge on pumpkins. The survey was fine-grid-intensive, targeting specific pumpkin farmers in each sub-county. The survey took 10 days to survey the two RSUs.

Germplasm Identification

All the 155 accessions were planted in Chuka University teaching farm on 23rd May, 2015. Those that bore leaves, flowers and fruits were used for taxonomic identification in order to get complete description of their appearance. Pumpkin leaves, and stalks attached to the main vine, tendrils, and flowers were excised from each accession. The samples were placed between two newspaper pages, mounted on a hard paper and labeled to make a herbarium and then pressed between two wooden boards of the same size as the newspaper page. The boards were made of smooth timber with grid square open spaces to allow free air circulation. The samples were then dried at room temperature for one month. Seeds were extracted from fruits of each accession and dried at room temperature until they attained the required moisture content. Fifty seeds of each accession were packaged in zip lock polythene bags to accompany the corresponding herbarium (Nesbitt *et al*., 2010; Nesom, 2011; OECD, 2012; Purnomo, *et al*., 2015). The herbaria of 96 accessions were taken to the National Museum of Kenya (NMK) for taxonomic identification and classification.

Data Analysis

Information from 76 questionnaires of farmers interviewed was analyzed using Statistical Analysis System (SAS) program. All qualitative data were numerically coded and arranged in nominal categories. Frequency or percentage for each descriptor state was calculated and data subjected to Chi-square analysis at $P = 0.05$.

RESULTS

Local Survey

The survey took five days in each RSU and a day in each sub-county. The exercise was conducted from 26th - 30th March, 2012 in Kakamega and 16th - 20th April, 2012 in Nyeri. A total of 34 farmers from Kakamega Central, Kakamega East, Kakamega South, Butere and Khwisero Sub-counties of Kakamega, and 42 from Mathira East, Mathira West, Nyeri Central, Tetu and Nyeri South Sub-counties of Nyeri were surveyed. The farmers surveyed were high in Mathira East and low in Nyeri South and Butere (Figure 1).

Pumpkin Production

A total of 155 pumpkin landraces were collected during the survey. All the farmers surveyed had grown pumpkin or were caring for volunteer pumpkin crops. Most of these farmers intercropped pumpkins with main crops. Local variegated landraces were cultivated by majority of farmers, compared to exotic green-leafed ones. Kakamega East farmers cultivated exotic green-leafed accessions and Kakamega South the local variegated landraces (Figure 2). Farmers cultivated more local variegated landraces, while cultivation of similar number of local and exotic cultivars was done to a limited extend. Farm size for most of the farmers surveyed were half a hectare (Table 1).

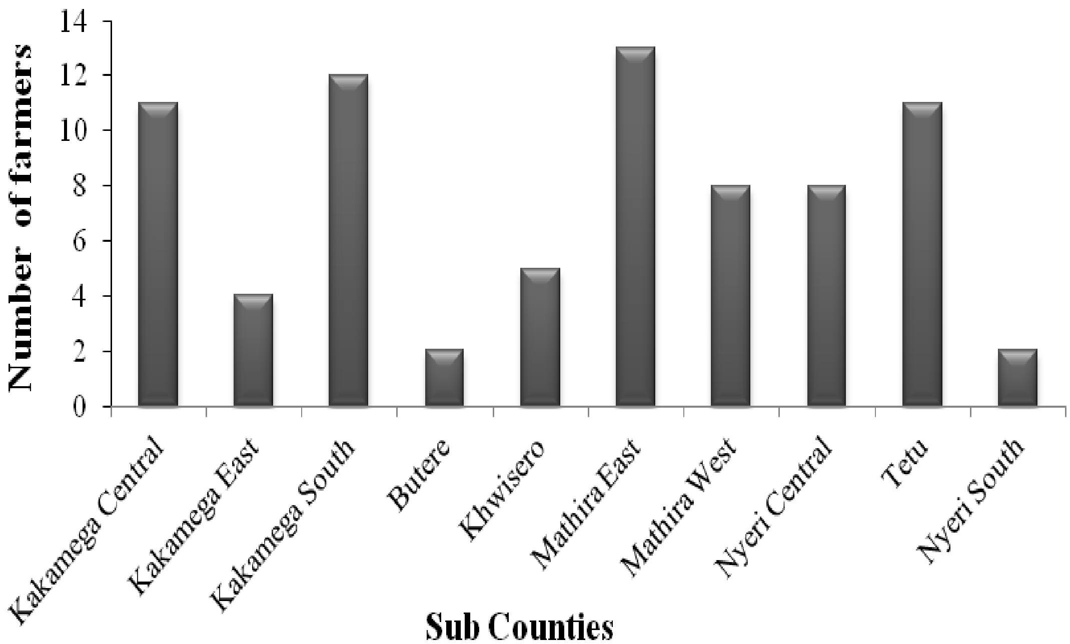

Figure 1: Farmers surveyed in each subcounty

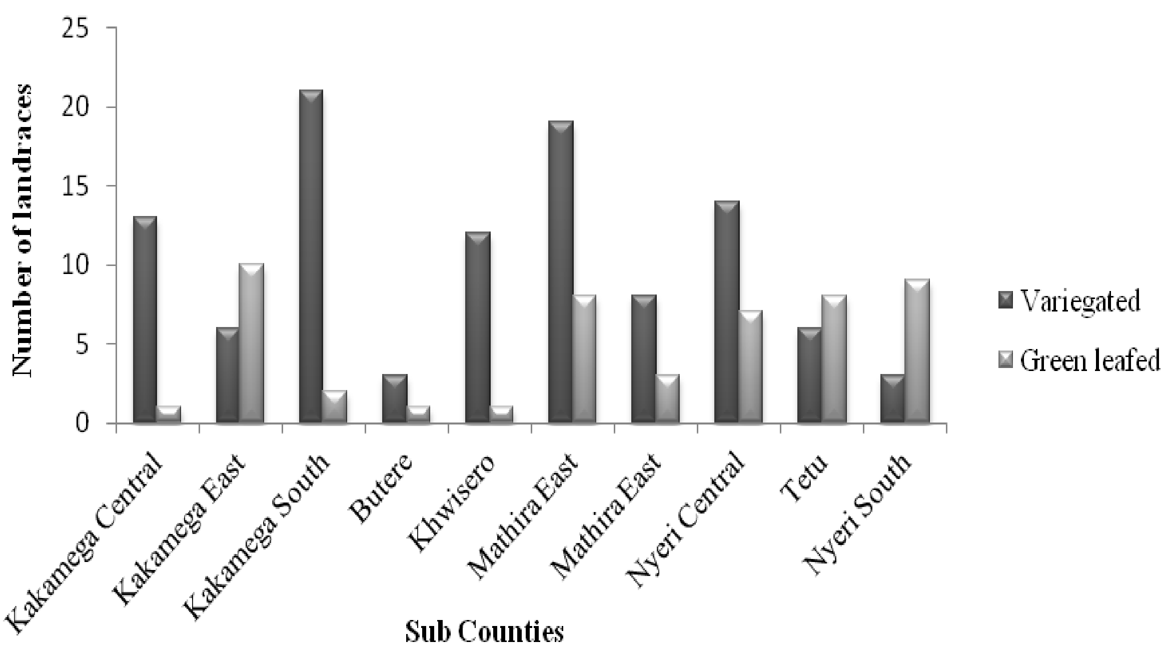

Figure 2: Type of pumpkin landraces grown in each sub-county

Table 1: Frequency of cropping patterns, type of pumpkin and farm sizes among farmers

Cropping patterns	**%**	**Obs N**	**Exp N**	χ^2	**df**	***P*-value**
Intercropping	95	72	25.3	1.29	2	0.000
Mono-cropping	4	3				
Intercropping & Mono-cropping	1	1				
Total		76				
Type of pumpkin grown	**%**	**Obs N**	**Exp N**	χ^2	**df**	***P*-value**
Local	59	45	25.3	23.1	2	0.000
Exotic	19	14				
Local and exotic	22	17				
Total		76				
Farm size holdings	**%**	**Obs N**	**Exp N**	χ^2	**df**	***P*-value**
Quarter ha	9	7	10.9	30.8	6	0.000
Half ha	34	26				
Three quarter ha	12	9				
One ha	20	15				
One half ha	11	8				
Two ha	9	7				
Total		76				

Pumpkin Utilization

Pumpkin was not cultivated as priority food crop by all the farmers. Majority of the farmers cultivated them mainly for food and income. They only traded on the surplus fruits and leaves. However, one farmer cultivated pumpkins for income only. Other farmers cultivated pumpkin for medicinal purposes, supplementary and for both human and animal food (Table 2). Pumpkin fruits and leaves were consumed by all the farmers after boiling. Seeds were consumed after roasting or were eaten raw after removing the outer cover. Some farmers mixed seeds with cereal grains to grind into flour. Majority of the farmers utilized fruits and leaves as food during drought. Whole pumpkin fruits, leaves, seeds, flowers and the vines were utilized only by one farmer (Table 2).

Table 2: Frequency of pumpkin utilization by farmers

Pumpkin utilization status	**%**	**Obs N**	Exp N	χ^2	**df**	***P*-value**
Food only	33	25	12.7	1.21	5	0.000
Supplemental food	4	3	12.7			
Food and income	57	43	12.7			
Income	1	1	12.7			
Human and animal food	3	2	12.7			
Medicinal	3	2	12.7			
Total		76				
Pumpkin parts utilized	**%**	**Obs N**	Exp N	χ^2	**df**	***P*-value**
Seeds	24	18	19.0	26.63	3	0.000
Whole plant (leaves, fruits, seeds & vines)	1	1	19.0			
Fruits & seeds mixed with other food stuff	37	28	19.0			
Fruit & leaves used during drought	38	29	19.0			
Total		76				

Indigenous Traditional Knowledge (ITK)

There were beliefs that pumpkin was for the children and pregnant women, a poor man's crop or for the lazy. There were other believes such as children could have delayed speech if they consumed a lot of pumpkins, and a folklore "brave men do not eat pumpkins" when going for war in Nyeri. These beliefs and folklore were gender-biased and they contributed towards hampering the production of pumpkins. A belief that pumpkin cured worms when cooked and eaten with the outer peel and that an elephant that came in Murumba village in Kakamega deposited many seeds from its dung that resulted in proliferation and abundance of pumpkins, helped in promoting production of the pumpkins. Indigenous knowledge such as the use of organic manure to enhance fruiting and vegetation longevity during dry seasons; restraining from leaf plucking to prevent fruit rotting or abortion of already formed fruits/flowers, and to prolong fruit shelf life. Discouraging of the main vine and lateral stems movement to avoid reduced fruiting and flower set promoted production of pumpkins (Person. Comm. Key Informant Farmers, 2012).

Seed Sources

Retained seed was used for planting by all the farmers surveyed. The seeds of most accessions were originally inherited from the past generations (Table 3). Some of the accession seeds were extracted from fruits bought in markets within the RSUs and their source of origin was not known. Other seeds were borrowed far beyond or within the RSUs, or bought from a market in Nairobi. Some of the seeds were conveyed from Mbale, in Uganda and United States of America. Seeds were also borrowed from the neighboring Counties in the year 2009, and others brought by a Non-Governmental Organization through a programme called Rural Outreach Programme in 2008. Some of the exotic green-leafed cultivars were introduced by Kenya Institute of Organic Farming in Kakamega East (Table 3).

Seed Selection

Most farmers selected seeds for planting in the next season. Selection criteria differed significantly among farmers (Table 4). Most accessions were selected based on fruit and leaf quality and drought tolerance (Table 4). Some farmers surveyed did not select, and others selected and mixed seeds of different accessions (Plate 1).

Table 3: Frequency of farmers planting pumpkins and the original seed sources

Cultivation of accessions	**%**	**Observed N**	**Exp N**	χ^2	**df**	***P* -value**
Planted pumpkin	84	64	38.0	35.579	1	0.000
Volunteer plants	16	12	38.0			
Total		76				
Source of original seeds	**%**	**Observed N**	**Exp N**	χ^2	**df**	***P* -value**
Inherited	63	97	17.2	442.89	8	0.000
Market within RSUs	13	20				
Borrowed outside RSUs	5	8				
Borrowed within RSUs	13	20				
Nairobi Market	1	2				
Mbale, Uganda	1	1				
USA	1	1				
ROP	2	3				
KIOF	2	3				
Total		155				

Table 4: Frequency for seed selection and selection criteria among farmers

Seed selection type	**%**	**Obs N**	**Exp N**	χ^2	**df**	***P* -value**
Good seed selection	89	68	25.3	1.079	2	0.000
No seed selection	7	5				
Poor seed selection	4	3				
Seed selection criteria						
Drought tolerance	19	29	12.9	1.315	11	0.000
Nutrition and medicinal purposes	5	7				
Fruit and leaf quality	28	43				
Pest and disease Resistant	2	3				
Volunteer	2	3				
Food supplement	3	5				
Minimal input and labour requirement	14	21				
Number of fruits	5	7				
Market requirement	7	11				
Long vegetation and fruit storage period	4	6				
No reason specific reason	10	16				
Leaf and fruit	3	4				

Plate 1: Seed mixtures stored by farmers

Plate 2: Appearance of pumpkin seeds dried above fire

Seed Storage

Farmer's stored planting seed in different forms, methods and location. The preferred form of storage by most of the farmers was seed (Table 5). The method and location favoured for most of the accessions was storing in plastic polythene bags on shelves, racks, raised place or on the floor on a section not frequently accessed in a family house. Storing in a gourd, open plastic containers, above fire, on a rack in a rented store or on farm with fruit attached to the plant were the least favoured methods and locations by the farmers (Table 5).

The favoured method and location storage combination was the use of plastic polythene bags, in a family on shelves or on the floor (Table 6). Farmers did not use any specific seed protection mechanism when storing their seed. One farmer in the survey area used firewood smoke to protect his pumpkin seeds from pests (Plate 2). There were no special containers used by farmers for seed preservation or storage, but plastic polythene bags, old newspapers or plastic containers were mostly used. Whole pumpkin fruits in most of the accessions were stored to be used for extracting seeds for the next crop. Seed cleaning and packaging was not done by all the farmers.

Table 5: Frequency of storage forms, methods and locations of the accessions among farmers

Storage forms	**%**	**Obs N**	**Exp N**	χ^2	**df**	***P*- value**
Seed stored	54	41	15.2	62.8	4	0.000
Fruit stored	21	16	15.2			
Seed and fruit stored	16	12	15.2			
No. seed/fruit stored	6	5	15.2			
Mixed seed stored	3	2	15.2			
Total		76				
Storage method						
Plastic polythene	40	62	25.8	160.1	5	0.000
Wrapped on old newspaper	4	6	25.8			
Stored in Guard	3	5	25.8			
Stored in open Plastic containers	2	3	25.8			
Stored as whole fruits	41	63	25.8			
Stored on metal or plastic plates	10	16	25.8			
Total		155				
Storage location						
Above fire	1	2	22.1	2.4	6	0.000
On or in a cabinet in kitchen or house	21	32	22.1			
On rented store rack	1	2	22.1			
Farm store	21	33	22.1			
Family house on shelves etc or on floor	52	81	22.1			
Outside house on rack	2	3	22.1			
On farm and fruit attached to plant	1	2	22.1			
Total		155				

Table 6: Cross tabulation of storage method and location of pumpkin accessions among farmers

Storage method	Above fire	Kitchen cabinet in or house	Rented store rack	Farm store	Family house shelves or floor	Outside house on rack	On farm fruit on plant	Total
Plastic polythene bags	0	9	1	13	39	0	0	62
Wrapped on old newspaper	2	4	0	0	0	0	0	6
Gourd	0	5	0	0	0	0	0	5
Open Plastic containers	0	0	0	0	3	0	0	3
Fruit stored	0	0	1	20	37	3	2	63
Metal or plastic plates	0	14	0	0	2	0	0	16
Total	2	32	2	33	81	3	2	155

Germplasm Conservation

Most farmers conserved only local accessions, although exotic and both local and exotic cultivars were also conserved by some farmers. Likewise, the local accessions conserved were more compared to the exotic green-leafed ones (Table 7). Cultivation of exotic pumpkin cultivars was high in Nyeri compared to Kakamega.

Pumpkin Production Constraints

Majority of the farmers reported no constraints in production of pumpkins. The constraints experienced by farmers while cultivating pumpkins varied from fruit rotting, fruit and flower abortion, wasps and fruit flies, leaf rollers, pest attacks on flowers, fruits and leaves, fruit warts, rats, porcupines, moles, blights, mildews, chlorosis, browning and death of young and old leaves, small unmarketable and low priced fruits and small land parcels (Table 8). Piercing of fruits by wasps and fruit flies was most problematic constraint reported by the farmers. Other major constraints reported included rodents, fruit rotting, and warts on fruit surfaces and pest attacks. Pest and disease incidences were mostly observed on exotic green-leafed cultivars. There were many moles in Kakamega and many porcupines in Nyeri. Fruit rotting was high in Nyeri due to prevalence of wasps and fruit flies. Warty surfaces were common on fruits of exotic green-leafed cultivars.

Table 7: Frequency of farmers and type of germplasm conserved for the accessions

Conservation frequency	**%**	**Obs N**	**Exp N**	χ^2	**df**	***P*-value**
Local	59	45	25.3	23.1	2	0.000
Exotic	19	14	25.3			
Local and exotic	22	17	25.3			
Total		76				
Conserved germplasm						
Local	68	105	77.5	19.52	1	0.000
Exotic	32	50	77.5			
Total		155				

Table 8: Frequency of pumpkin constraints encountered by farmers

Pumpkin constraint, n = 76	%	Obs N	Exp N	χ^2	df	*P*-value
Fruit rotting	10	8	5.8	80.7	12	0.000
Piercing by wasps and fruit flies	13	10	5.8			
Fruit, leaf and flower abortion	3	2	5.8			
Leaf rollers	3	2	5.8			
Pest attacks on flowers, fruits and leaves	7	5	5.8			
Warts on fruit surfaces	8	6	5.8			
Rodents (rats, porcupine and moles)	12	9	5.8			
Blights and mildews (Downey and powdery)	1	1	5.8			
Chlorosis, browning, death of young/ old leaves	3	2	5.8			
Small unmarketable, low priced fruits	5	4	5.8			
Small land parcels reducing production	1	1	5.8			
Lack of fruits due to shortage of rains	3	2	5.8			
No constraints	31	24	5.8			

Taxonomic Identification

The voucher specimens of 96 accessions were delivered to NMK for taxonomic identification by a botanical specialist, who understood plant morphology and had experience in taxonomy of plants. All the accessions belonged to the *Cucurbitaceae* family. They were classified as: *Cucurbita moschata* (Lam.) Poir based on the Latin binomial system. The accessions were separated into two categories: green-leafed and variegated-leafed (Table 9). The cultivar names of the accessions were not indicated, because NMK had tools for wild plant collections only, save for a few crop species.

Table 9: Taxonomic classification of the accessions

Accession codes	Family	Genus	Species	Author	Common name	Type of accession	Region of collection
KK 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 17, 24, 26, 29, 30, 31, 32, 34, 36,38, 39, 40, 43, 44, 45, 46, 47, 48, 49, 50, 51, 52, 54, 56, 58, 59, 60, 62,63,64, 65,66, 67, 69 & 70	Cucurbitaceae	*Cucurbita*	*moschata*	Lam. Poir.	Pumpkin	Variegated	Kakamega
KK 15, 16, 35 & 55	Cucurbitaceae	*Cucurbita*	*moschata*	Lam. Poir.	Pumpkin	Green-leafed	Kakamega
NY 72, 79, 81, 83, 85, 86, 87, 90, 91, 93, 94, 95, 96, 97, 98, 99, 102, 106, 109, 111, 112,114, 115, 116, 117, 118, 120, 123, 125, 129, 133, 135, 139, 141, 142, 143, 144, 153 & 154	Cucurbitaceae	*Cucurbita*	*moschata*	Lam. Poir.	Pumpkin	Variegated	Nyeri
NY 74, 77, 100, 134 & 147	Cucurbitaceae	*Cucurbita*	*moschata*	Lam. Poir.	Pumpkin	Green-leafed	Nyeri

DISCUSSION

Survey Scope

During the survey 76 farmers participated in the exercise, a large number of farmers was expected, but challenges such as failure to access some of the targeted areas due to poor road conditions; long and rough roads to cover an otherwise would be short distances, lack of agriculture staff in some locations which made it difficult to trace the right farmers; Information barrier due to patriarchal family system in some instances which hindered information divulge without permission from the counterpart; transport scarcity and information delivery failure delayed the start of the survey in some sub counties which contributed to the low number of respondents surveyed.

Pumpkin Production

Local pumpkins were mostly cultivated by majority of the farmers. One of the reasons for their preference was their cultural identity. This signified their value and importance in the local cultures (Ngugi *et al*., 2007). Other reasons included biotic and abiotic stress tolerance; ability to grow naturally with little or no care using organic manure which is locally available; retained seeds recycled every year without significant yield reduction, and their good taste of leaves and fruits (Person. Comm. Key Informant Farmers, 2012). The local species have naturally evolved over the years in specific environments (Mooney and Cleland, 2001). This has enhanced their continued production and use (Irungu *et al.,* 2011). Maarten van (2013) reported pest resistance and abiotic stress tolerance, Onyango and Onyango (2005) low prevalence of pests and diseases, and Brown (2002) repelling of aphids by the silvery-leaves of local landraces than the green-leafed pumpkins. Exotic green-leafed cultivars were also grown by some farmers. They had low yields, pests and diseases were common on them, and their vegetative period was short. Wien *et al*., (2004) stated that pest and disease attacks and poor adaptation result in low yields.

Weltzien and Fischbeck (1990) reported exotic cultivars not being superior to the local landraces. However, the response of genotypes in different locations, years or seasons, depends on the environmental interaction (Razim, 2011), because yields are polygenic in nature (Pandey *et al.,* 2008). Low yields in present pumpkins compared to the past ones, but also high yields were reported by the farmers. The low yields were attributed to intercropping of pumpkins by majority of the farmers, who were only interested in obtaining full yield of the main crops. Momirovic *et al*. (2015) reported significant high yields in a sole crop of pumpkin than in intercropping. Intercropping reduces yields through competition for assimilates (Maynard, 2007), when interspecific and intraspecific competition are high in the same environment (Momirovic *et al*., 2015). The increased yields obtained were attributed to trellising of pumpkins onto the main crop that enhanced better light interception (Chukwudi and Agbo, 2014). This result was in agreement with Chukwudi and Agbo (2014), who reported increased number of branches, leaves, and vine length and leaf area in trellised plants than non-trellised plants, owing to good exposure to and minimal competition for light.

Pumpkin Utilization

Farmers mainly cultivated pumpkins for food and income. They only sold the surplus because pumpkins have considerable potential as income earners (Onyango, 2002). Onyango (2007) reported that pumpkin leaves are among the African Leafy Vegetables important for food and income in many parts of western Kenya. Commercialization of pumpkins by farmers in Kakamega and Nyeri was necessitated by closeness to nearby towns. In the survey area medicinal application of pumpkins based on farmer training, indicated that fruits and leaves were helpful in maintaining body health, and the seeds were useful in preventing some sicknesses when consumed regularly (Mavek et al., 2007). Ondigi *et al.* (2008) reporting on farmer opinions as influenced by visits of health, social or agricultural workers indicated that pumpkin and pumpkin products boosted immunity and strong bones, the seeds improved eyesight of people above 30 years, acted as iron supplement, provided vitamin E; cleaned kidneys, treated stomach ulcers and acted as de-wormers, laxatives, and against flatulence and diarrhea. Fruit stalks were used to treat heartburns and the roots as medicine for pregnant mothers.

Pumpkin fruits have active compounds such as: vitamin C and E, minerals, pectin and carotenoids. Carotenoids catch free radicals and active atomic oxygen in human body by acting as biological antioxidants, protecting cells and tissues from the damaging effects of free radicals and singlet oxygen. Xanthophyll pigments (lutein and zeaxanthin) in fruits play protective role for coronary heart diseases and stroke, cataract and macular degeneration (Kulaitiene *et al.,* 2014). Farmers in the survey area also used pumpkin as supplemental food for human and animal feed during drought. Ondigi *et al.* (2008) reported that pumpkins are regarded as supplementary food by most of the farmers. In the present study, pumpkin fruits were fed to livestock during drought due to shortage of fodder. The vines and leaves were only fed during farm clearing when whole crop was uprooted. They are good sources of proteins and fibre (Kulaitiene *et al.,* 2014), and nearly all nutrients required for good human and animal health (Ondigi *et al.,* 2008).

Pumpkins were consumed most of the farmers during drought. They play an important role in maintenance of nutritional levels during the long dry seasons, when other fresh vegetables are not available. Their fruits stored for long up to 6 months (Onyango, 2002), or over 8 months with stalk attached to the fruit (Ondigi *et al.,* 2008). Traditional pumpkins were mostly maintained by farmers (Thies, 2000), because they have strong cultural importance and better withstanding of adverse weather conditions (Oloyede, 2014). They possessed important genes for drought resistance (Marilene *et al*., 2012), and could grow in a wide range of environments (Ondigi *et al.*, 2008). They were grown with ease using minimal external inputs, low rainfall and poor soils (Muthoni *et al*., 2010). Farmers consumed pumpkin seeds raw, roasted or after grinding into flour when mixed with cereal grains. Kulaitiene *et al.* (2014) reported seeds used either for direct consumption or for preparation of other foods such as syrups, jellies, jam, and purees. Processed pumpkin flour had longer shelf life, flavour, sweetness, deep yellow orange color and considerable amount of dietary fiber. Pumpkin fruits were cooked then mashed into watery substance and mixed with wheat flour for baking or mixed with maize and beans or consumed as snacks after boiling. Kulaitiene *et al.* (2014) reported pumpkin supplementing cereal flours in bakery products, soups, sauces, instant noodles and also as a natural colouring for food.

Indigenous Traditional Knowledge (ITK)

To help manage and conserve pumpkin diversity, cultural beliefs, folklores and ITK were used. Cultural beliefs safeguarded growing and development of pumpkins (Ondigi *et al*., 2008). They set out rights and responsibilities of the local communities (Swiderska, 2009). Indigenous technical knowledge ensured traditional knowledge fulfilled community needs and addressed new challenges (Swiderska, 2009). Folklores were important in preserving the original local landraces (Howard, 2006). These socio-cultural values safeguarded the diversity of local landraces (Ondigi *et al*., 2008) from wanton destruction by cautioning the way indigenous people used their resources (Swiderska, 2009). However, some of these values were gender-biased, which hindered the overall expansion of pumpkin production (Ondigi *et al.*, 2008).

Some of the socio-cultural values are maintained, but others have been weakened and eroded (Swiderska, 2009). The weakening among other reasons has contributed to loss or erosion of local landraces (Bott, 2007). The elderly had made significant contributions to the maintenance of local landraces through traditional sustainable resource use practices and culture-based respect for nature (Beltran, 2000). For instance, a proverb “pumpkin in the old homestead must not be uprooted” was used to plead with and admonish people not to destroy their cultural identity (Bott, 2007). In Kenya, the socio-cultural values are on the decline due to spread of western cultures in the rural areas. They have been lost or modified, or are selectively recognized. In most areas, they have been lost entirely, with some only remaining amongst the elderly (Swiderska, 2009). Abandonment and neglect of these the socio-cultural values that safeguard genetic diversity of local landraces, that have all relevant allelic diversity necessary for pumpkin improvement could lead to loss of the entire gene pool (Mwaura, 2004; D’hoop *et al*., 2010).

Seed Source

The seeds of local accessions were mostly inherited from past generations. Ndoro *et al*., (2007) reported seeds of landraces that have been maintained by farmers over long periods of time. Most of the farmers in the survey used retained seed, although some used borrowed seed from neighbours and relatives. Ndoro *et al*. (2007) reported retained seed constituting the bulk of the pumpkin seed source, and borrowing by a few of the farmers. Pumpkin fruits were also bought from local or outside markets and seed extracted. The disadvantage of buying fruits from the market was that their source was not known. Longley *et al*. (2001) and Ndoro *et al*. (2007) reported seed sources to include local markets. Informal seed supply systems are critical components of resource-poor farming systems (Bates *et al*., 2011), they hinge on the cultural heritage where farmers save, sell and exchange germplasm (Majuju, 2010). Some farmers brought in accession seeds from beyond Kenyan borders or introduced by nongovernmental organizations. In the present study, farmers reported that the introduced exotic pumpkins did not perform better than local species. Pest and diseases and low yields were common on these cultivars. Institute of Biodiversity Conservation (IBC, 2007) reported that exotic species result in unknown disease and pest problems. Purposeful introduction of exotic species by humans threaten native species with extinction by hybridization and introgression. Hybridization reduces local species through inbreeding depression, genetic mixing, genic dilution and dispersion. Introgression causes genetic swamping of the local species gene pool, creating hybrids that supplant the native stock (Rhymer and Simberloff 1996; Potts, *et al.*, 2001). Unequal gene exchange between the local species and introduced varieties affects adaption (Grant *et al*., 2005), and threatens local species diversity through genetic erosion (Mathur, 1995; Su *et al*., 2003) and existence (Rhymer and Simberloff 1996; Potts *et al.*, 2001).

Selection, Storage and Conservation of Seeds

Farmers in the survey selected accessions for the next planting after harvesting. The selected accessions were based taste of fruits and leaves. Rajendran *et al.* (2014) reported a strong relationship between dietary and farm produce diversity. Selection based on quality and preference can affect plant diversity if the associated accessions have better nutritional profile (Kulkarni and Gokhale, 2014). Diversity is significantly related to diet and consumption of own-produced than market-purchased varieties. Farmers extracted seed during fruit utilization or before planting. Seed cleaning was not done by all the farmers. Seed extraction and cleaning can influence pumpkin genetic diversity. Pumpkin genetic diversity loss can result from inadvertent selection, such as throwing away smaller or lighter seeds during the cleaning process. The loss can also be intentional, if larger, more uniform, or faster germinating seeds are selected, and others are excluded. In both cases, if the selected characteristics have a genetic basis, loss of diversity occurs. However, there may be negligible genetic effects if the losses are small (USDA, 2006).

Farmers mostly used seed size to select seeds of pumpkin accessions. Some did not select seeds, while others selected and mixed seeds of different accessions. Good seed selection improves physiological quality by eliminating small, empty and under-developed seeds. Seed size variation of accessions can be caused by heredity, environmental or developmental factors. Small seeds yet viable are deliberately eliminated by farmers based on the assumption that seed size and vigour are correlated.

Selection based on seed size can change the genetic constitution of the accessions by eliminating part or whole family by discarding small seeds (Schmidt, 2000). The accessions were stored in seed form by majority of the farmers in plastic polythene bags in a family house. Seed packaging and storage method can result in pumpkin loss of diversity from mortality of some seeds in storage (USDA, 2006). Storage locations and methods determine vulnerability of seeds to pests, diseases, physiological deterioration, quantity and quality, act as forces for selecting seeds that are better adapted and are more likely to survive until the next planting season (Jarvis *et al.*, 2000). In the survey, one farmer stored seeds above fire. Storage above fire protects the seeds from pest, since smoke and heat produced by the fire creates a hostile environment for pests; however, it also affects seed viability (Bates *et al*., 2011).

The seeds of local species were mostly conserved *in-situ* by farmers. They serve as a genetic resource for breeding and improvement of well-adapted species (Porth and El-kassaby, 2014). Conservation within local environment ensures adaptation is maintained within the farming systems. On-farm conservation is central to the local communities, as it conserves not only the existing germplasm, but also conditions allowing development of new germplasm (Jarvis *et al*., 2000). Local agro-ecological conditions play an important role, ensuring crop genetic diversity remains directly in the hands of the primary users (Kumar *et al.*, 2010). This strategy empowers and recognizes individual farmers and local communities as the curators of local genetic diversity and indigenous knowledge (Jarvis *et al*., 2000). Exotic cultivars conserved by some of the farmers, can result in genetic erosion or threat to the local species (Jarvis *et al*., 2000). Prevention of the local species from relative erosion or threat can be done through establishment of conservation priorities (Kumar *et al*., 2010). This require collection, *in-situ* conservation and enhancement programmes involving farmers, local communities, breeders and other stakeholders in maintenance, restoration and improvement (Institute of Biodiversity Conservation, 2007). These tactics enhance the local species genetic gain for a number of useful traits and vitality to withstand diverse biotic and abiotic stresses under changing and unpredictable environmental conditions (Porth and El-kassaby, 2014).

Pumpkin Production Constraints

Pumpkin constraints were not reported in local accessions by most of the farmers. However, reported constraints included fruit piercing by wasps and fruit flies, rodents (rats, porcupine and moles), fruit rotting, warty fruits, pests and diseases. The exotic cultivars grown by some of the farmers were highly susceptible to pests and diseases, produced low or no yields under severe infestation (Ndoro *et al.,* 2007) and most of the fruits were warty. Constraints such as lack of quality seeds (Onyango and Onyango, 2005), temperature rise, irregular and unpredictable rainfall (GoK, 2010) has hampered increased production and diversity of pumpkins. To mitigate the effects of unpredictable drought events farmers have continued production of locally adapted and drought tolerant crops as a strategy (Munisse *et al*., 2011). Exotic cultivars planted by some farmers, has resulted in unknown diseases and pests, which can lead to genetic vulnerability of local species (Institute for Biodiversity Conservation, 2007). Planting of disease-tolerant varieties and good cultural practices will help farmers to control some of these important diseases (Wyenandt, 2006). Most of the farmers surveyed had land sizes below one hectare. Declined land sizes due to population pressure (Maina *et al*., 2010; Place *et al*., 2006), has adversely affected production of pumpkins that require large area for cultivation (Oloyede *et al*., 2013a). These factors contributed to low cultivation and poor production of pumpkins in the survey area.

Taxonomic Identification

In the present study, three (Luhya, Kikuyu and Luo) communities were surveyed. They all had their local names that they used to commonly refer to different pumpkin species. Nesbitt *et al*. (2010) reported different local names, or one name describing different species with similar uses or taste. Plant identification computes a species taxon that a plant belongs (Nesbitt *et al*., 2010). It relies on phenotypic appearance that involves listing of observable characteristics of organisms and matching them with a diagnostic of a particular group (Echessa, 2011). Thus, taxonomy is a vital (Bennett and Balick, 2014), method in identification of species (Echessa, 2011). In the study, 96 local and exotic species were identified. They all belonged in: *Cucurbitaceae* family and *Cucurbita moschata* (Lam.) Poir species. The botanical names were based on the Latin binomial system (Nesbitt *et al*., 2010). Nesom (2011) reported *Cucurbita moschata* species identified as Duchesne ex Lam., or Duchesne ex Poir, based on *Cucurbita pepo* var. moschata Duchesne ex Lam.

The cultivar names of different accessions identified were not added. The species name alone is insufficient. Sub species or varietal names must be provided along with the cultivar name (Bennett and Balick, 2014). Distinct forms of cultivated plants bear an additional formal name: a cultivar name appended to the main botanical name (Nesbitt *et al*., 2010). The cultivar names were not added, since NMK had tools for wild plant collections only, save for a few crop species with special tools. Nonetheless, *Cucurbita moschata* species elsewhere has many cultivars, including: butternut squash, golden cushaw, calabaza, winter squash, crookneck squash, neck pumpkin, Tahitian squash, West Indian pumpkin, large cheese pumpkin, Long Island cheese pumpkin, Tennessee sweet potato, Kentucky field pumpkin and Dickinson pumpkin (Nesom, 2011), Buckskin, Thai and Cheese (Echessa, 2011), La Primera, Seminole, Soler, Golden crookneck, Waltham Butternut, Zenith and Upper Ground Sweet Potato (OECD, 2012).

The collected accessions were grouped as green-leafed or variegated-leafed. Brown (2002) reported that variegated silvery-leaves repel aphids. The collected accessions portrayed variation in leaf colour, fruit and seed characters. The fruit ribs were smooth or rounded, with verrucose or granulose surfaces in some of the green-leafed accessions, fruit rind colour varied from light-green to uniform dark-green or cream or yellow spots, light to dark, orange, or completely grey and cream white surfaces (Purnomo, *et al*., 2015). The seeds had smooth or tubercular coats, intermediate to very large seed size; white, yellow-white, cream-yellow, light-brown or tan and brown in colour, narrowly-elliptic, elliptic to broadly-elliptic shapes, with blunt or pointed hilum ends. Nesom (2011) reported differences in growth habit, stems, leaves, fruit peduncles, fruit size, shape, surface, colour, seed shape, size and colour of five domesticated *Cucurbita* species (OECD, 2012).

CONCUSIONS AND RECOMMENDATIONS

In Kenya, pumpkins are not grown as a priority crop by most farmers, making them risk genetic loss. Growing native species together with exotic ones can cause genetic erosion and loss of diversity. The local pumpkins are well-adapted to the local environment and are tolerant to biotic and abiotic stresses. This diversity can be harnessed to improve production and income for small-scale farmers. They also have the potential of promoting health, nutrition and food security for the poor small-scale farmers.

Farmers in the survey area used cultural beliefs, folklores and indigenous traditional knowledge to safeguard growth and development, address new challenges and preserve genetic diversity of local pumpkins. These socio-cultural values are slowly weakening among farmers and communities. It is, therefore, necessary to sensitize them about the need to promote pumpkin production and consumption.

Lack of quality seed has hindered expansion of pumpkin production. Strengthening of informal seed systems should be promoted by governmental and other stakeholders to ensure quality seed is available. Empowering farmers to be custodians and recognizing them as curators of local genetic diversity and indigenous knowledge should be encouraged to avoid further genetic erosion and loss of genetic diversity. Seed storage practices should be strengthened and on-farm conservation of species within the local agro-ecological conditions should be maintained to ensure sustainable pumpkin production for food security.

Plant identification is critical to reproducibility, documentation, and prediction of plant species. Lack of proper identification ignores history, similarities and differences between living things. For plant species to become useful they should be properly identified and accessioned correctly. This can be achieved by collecting, identifying and conserving ex-situ or in-situ for breeders and other plant users to utilize them in improving the local species.

ACKNOWLEDGEMENT

This research was funded by KAPAP to whom we are most obliged. Authors are grateful to Ministry of Agriculture staff in Kakamega and Nyeri counties, Mr. Manyengo, KAPAP representative in Kakamega, and farmers who offered germplasm and participated in the survey to give all important information for their cooperation and collaboration.

REFERENCES

Bates, R.M., Bicksler, A.J., Burnette, R., Gill, T., Yoder, L.M., Ricciardi, V. and Srigiofun, Y. 2011. Strengthening informal indigenous seed systems in Southeast Asia. ECHO Asia Impact Center. www.asia.echonet.org

Beltrán, J. 2000. Indigenous and traditional peoples and protected areas: Principles, guidelines and case studies. IUCN, Gland, Switzerland and Cambridge, UK and WWF International, Gland, Switzerland.

Bennett, B.C. and Balick, M.J. 2014. Does the name really matter? The importance of botanical nomenclature and plant taxonomy in biomedical research. J. Ethnopharmacology, 152:387–392.

Bott, K. 2007. Pumpkin fruit/pumpkin root: Participatory theatre in a Ugandan Prison. In: P’Bitek, Okot. Song of Lawino. Dar es Salaam, Tanzania: East Africa Publishing, 1972. Platform, Vol. 2, No. 2.

Brown, R.N. 2002. Traditional and molecular approaches to zucchini yellow mosaic virus resistance in *Cucurbita.* A Doctor of Philosophy in Horticulture Thesis, Oregon State University.

Chukwudi, U.P. and Agbo, C.U. 2014. Leaf and fruit yield performance of *Telfairia occidentalis* Hook F. (fluted pumpkin) as influenced by fruit size. Not Sci Biol., 6(4):509-514.

Chweya, J. 1994. Potential for agronomic improvement of indigenous plant germplasm in African agriculture: A case study of indigenous vegetables in Kenya. *In*: A. Putter (Ed.). Safeguarding the genetic basis of Africa's traditional crops. Proceedings of ACTA/IPGRI/KARI/UNEP Seminar, pp. 105-113. CTA, the Netherlands/IPGRI, Rome, Italy.5-9th October, 1992, Nairobi, Kenya.

D'hoop, B.B., Paulo, M.J., Kowitwanich, K., Senger, M., Visser, R.G.F., Van Eck, H.J. and van Eeuwijk, F.A. 2010. Population structure and linkage disequilibrium unraveled in tetraploid potato. Theor. Appl. Genet., 121:1151–1170.

Echessa, A.C.P. 2011. Evaluation of the pumpkin varieties and determination of their micronutrients in the Lake Victoria Basin. A Master of Science Thesis, Kenyatta University, Nairobi, Kenya.

Engels, J.M.M., Arora, R.K. and Guarino, L. 1995. An introduction to plant germplasm exploration and collection: Planning, methods and procedures, follow-up. *In*: Guarino, L., Ramanatha, Rao V. and Reid, R. (Eds.). Collecting Plant Genetic Diversity. Technical Guidelines. CAB International, p. 31-63.

FAO. 2003. FAOSTAT Agriculture Data. http://www.apps.fao.org/page/collections?subset=agriculture.

G.o.K. 2010. National Climate Change Response Strategy. Ministry of Environment and Natural Resources, NHIF Building, Ragati Road, Upperhill, Nairobi.

Grant, P.R., Grant, B.R. and Petren, K. 2005. Hybridization in the recent past. American Naturalist, 166: 56–67.

HCDA. 2008. Horticulture data 2005-2007 validation report. Horticultural Crops Development Authority, April, 2008, Nairobi, Kenya.

Howard, P. 2006. Gender bias in ethnobotany: Propositions and evidence of a distorted science and promises of a brighter future. *In*: P. Howard (Ed.). Women and Plants: Gender Relations in Biodiversity Management and Conservation. Zed Press and Palgrave Macmillan, London and New York.

Institute for Biodiversity Conservation. 2007. *The State of Plant Genetic Resources for Food and Agriculture*. The 2nd Country report on the state of PGRFA to FAO, August 2007, Institute of Biodiversity Conservation (IBC), Addis Ababa, Ethiopia.

International Plant Genetic Resources Institute (IPGR). 2003. *Descriptors for melon* (*Cucumis melo* L.). IPGRI, Rome, Italy.

Irungu, C., Mburu, J., Maundu, P., Grum M. and Hoeschle-Zeledon, I. 2011. The effect of market development on-farm conservation of diversity of African leafy vegetables around Nairobi. Intern. J. Humanities Social Sci. 1(8):198-207.

Jaetzold, R. and Schmidt, H. 1983a. Farm Management Handbook of Kenya. Natural Conditions and Farm Information. Vol. II. B. Central Kenya. Ministry of Agriculture, Nairobi, Kenya.

Jaetzold, R., and Schmidt, H. 1983b. Farm Management Handbook of Kenya. Natural Conditions and Farm Information. Vol. III. West Kenya. Ministry of Agriculture, Nairobi, Kenya.

Jarvis, D.I., Myer, L., Klemick, H., Guarino, L. Smale, M., Brown, A.H.D., Sadiki, M. Sthapit, B. and Hodgkin, T. 2000. A training guide for in situ conservation on-farm. Version 1.International Plant Genetic Resources Institute, Rome, Italy.

Kassam, A. H., Velthuizen, H.T., Fischer, G.W. and Shah, M.M. 1991. Agro-Ecological Land Resources Assessment for Agricultural Development Planning. A Case Study of Kenya, p. 9-31. Resources Data Base and Land Productivity. Technical Annex 1, Land Resources. Land and Water Development Division, FAO and IIASA, Rome.

Kulaitiene, J., Jarienė, E., Danilcenko, H., Cerniauskienė, J., Wawrzyniak, A., Hamulka, J., and Edita Jukneviciene, E. 2014. Chemical composition of pumpkin (*Cucurbita maxima* Duch.) flesh flours used for food. J. Food, Agric. Env., 12 (3 and 4): 61-64.

Kulkarni, N., and Gokhale, C. 2014. Vegetable and fruit diversity in an Indian Community. Int. J. Food, Nutrition and Public Health, 7 (1): 13–24.

Kumar, S., Bisht, I.S., and Bhat, K.V. 2010. Assessment of genetic diversity among rice (*Oryza sativa* L.) landrace populations under traditional production using microsatellite (SSR) markers. Electronic Journal of Plant Breeding, 1(4): 474-483.

Longley, C., Jones, R., Ahmed, M.H., and Audi, P. 2001. Supporting local seed systems in Southern Somalia: A Developmental approach to agricultural rehabilitation in emergency situations. Agriculture Research and Extension Networks. Network Paper No. 115.

Maarten van, Z. 2013. Economic plant diversity and distribution: Application of spatial analysis for the conservation of germplasm diversity in Latin America. Ph.D. Thesis, Ghent University, Belgium.

Maina, F.W., Karugia, J.T., Nyikal, R.A., and Kimani, S.K. 2010. Enterprise prioritization and applications for soil fertility management and value chain research: The case of Kiambu District. Proceedings of the 12th Biennial KARI, Scientific Conference on Transforming Agriculture for Improved Livelihoods through Agricultural Products Value Chains, 8-12 Nov., 2010, KARI Headquarters, Nairobi, Kenya.

Marilene, H.D.S., Rosana, R., Leandro, S.A.G., Cláudia, P.S. and Messias, G.P. 2012. Agrobiodiversity in *Cucurbita* spp. landraces collected in Rio deJaneiro assessed by molecular markers. Crop Breed. Appl. Biotech., 12:96-103.

Mathur, P.N. 1995. Assessing the threat of genetic erosion. *In*: Guarino, L., Ramanatha Rao, V. and Reid, R. (Eds.). Collecting Plant Genetic Diversity. Technical Guidelines-2011 Update, CAB International. Chapter 4, p 1-7.

Mavek, G., Jadwiga, R., Honorata, D., Elvyra, J. and Judita, C. 2007. Quality of pumpkin cultivars in relation to sensory characteristics. Not. Bot. Hort. Agrobot. Cluj 36 (1):73-79.

Maynard, L. 2007. Cucurbit crop growth and development. Indiana CCA Conference Proceedings.

Momirovic, N., Oljaca, S., Dolijanovic, T., Simic, M., Oljaca, M. and Janoševic, B. 2015. Productivity of intercropping maize (*Zea mays* L.) and pumpkins (*Cucurbita maxima* Duch.) under conventional vs. conservation farming system. Turk. J. Field Crops., 20(1): 92-98.

Mooney, H. A., and Cleland, E. E. 2001. The evolutionary impact of invasive species. PNAS, 98(10):5446-5451.

Munisse, P., Andersen, S.B., Jensen, B.D. and Christiansen, J.L. 2011. Diversity of landraces, agricultural practices and traditional uses of watermelon (*Citrullus lanatus)* in Mozambique. Afri. J. Plant Sci., 5(2):75-86.

Muthoni, J., Nyamongo, D.O. and Mary, S. 2010. Participatory characterization and evaluation of some African leafy vegetables in Lari, Kiambu West District, Central Kenya. Journal of Horticulture and Forestry, 2(2):12-16.

Mwaura, F. 2004. African cultures and indigenous foods versus exotic foods. *In*: Networking Event on Indigenous Foods and Local Food Security. Second World Urban Forum Final Report. Coalition of African Organisations on Food Security, Sovereignty and Sustainable Development (COASAD), Dakar, Senegal.

Ndoro, O.F., Madakadze, R.M., Kageler, S. and Mashingaidze, A.B. 2007. Indigenous knowledge of the traditional vegetable pumpkin (*Cucurbita maxima/moschata*) from Zimbabwe. Afri. J. Agric. Research, 2(12):649-655.

Nesbitt, M., McBurney, R.P.H., Broin, M., and Beentje, H.J. 2010. Linking Biodiversity, Food and Nutrition: The Importance of Plant Identification and Nomenclature. J. Food Composition and Analysis, 23: 486–498.

Nesom, G.L. 2011. New State Records for Citrullus, Cucumis, and Cucurbita (Cucurbitaceae) Outside of Cultivation in the USA. Phytoneuron, 1: 1–7.

Ngugi, I. K., Gitau, R. and Nyoro, J. 2007. Access to high value markets by small holder farmers of African indigenous vegetables in Kenya, Regoverning Markets Innovative Practice series, IIED, London.

OECD. 2012. Consensus document on the biology of *Cucurbita* L. (squashes, pumpkins, zucchinis and gourds). Series on Harmonisation of Regulatory Oversight in Biotechnology, No. 53. ENV/JM/MONO (2012), 31.

Olosunde, M.A., Dauda, T.O. and Aiyelaagbe, I.O.O. 2010. Rapid Leaf Area Estimation of *Crytorchidmonteiroae*. J. American Sci., 6(12):1549-1553.

Oloyede, F.M., Agbaje, G.O. and Obisesan, I. O. 2013a. Effect of NPK Fertilizer on fruit yield and yield components of pumpkin (*Cucurbita pepo* Linn.).African J. Food, Agric., Nutri. Devt, 13 (3):7755-7771.

Ondigi, A.N., Toili, W.W., Ijani, A.S.M. and Omuterema, S.O. 2008.Comparative analysis of production practices and utilization of pumpkins (*Cucurbita pepo* and *Cucurbita maxima*) by smallholder farmers in the Lake Victoria Basin, E. Africa. Afr. J. Env. Sci. Tech., 2(9):296-304.

Onyango, M.O.A. 2002. African indigenous vegetables: Opportunities and constraints. *In*: Proceedings of the Horticulture Seminar on Sustainable Horticultural Production in the Tropics, October 3rd to 6th 2001, pp. 81-91. Jomo Kenyatta University of Agriculture and Technology, Juja, Kenya.

Onyango, M.O.A. 2003. Unexploited potential of African indigenous vegetables in Western Kenya. Maseno Journal of Education, Arts and Science. 4(1):103-122.

Onyango, M.O.A. 2007. Seed production and support systems for African leafy vegetables in three communities in western Kenya. Afri. J. Agric. Nutri. Dev. 7(3):1-16.

Onyango, M.O.A. and Onyango, J.C. 2005. Conservation and seed production of African leafy vegetables at Maseno University Botanic

Garden, Kenya. Afri. Crop Sci. Conference Proceedings, 7:1201-1204.

Pandey, S., Kumar, S., Choudhary, B. R., Yadav, D. S. and Rai, M. 2008.Component analysis in pumpkin (*Cucurbita moschata* Duch. Ex Poir.). Veg. Sci. 35(1):35-37.

Place, F., Njuki, J., Murithi, F. and Mugo, F. 2006. Agricultural enterprise and land management in the highlands of Kenya. *In*: Pender, J., Place, F. and Ehui, S. (Eds.). Strategies for Sustainable Land Management in the East African Highlands. International Food Policy Research Institute. Washington DC, USA.

Porth, I., and El-Kassaby, Y.A. 2014. Assessment of the genetic diversity in forest tree populations using molecular markers.Diversity:6, 283-295.

Potts, Brad M., Barbour, Robert C. and Hingston, A. B. 2001. Genetic pollution from farm forestry using eucalyptus species and hybrids: A report for the; RIRDC /LandWA/FWPRDC Joint Venture Agroforestry Program". RIRDC Publication No 01/114; RIRDC Project-3A (Australian Government, Rural Industrial Research and Development Corporation).

Purnomo., Daryono, B.S. and Sentori, M.B. 2015. Variability and intra-species classification of pumpkin (*Cucurbita moschata* (Duch. ex Lam.) Duch. ex Poir.) based on morphological characters. *In*: The 3rd International Conference on Biological Science 2013 (The 3rd ICBS-2013). Published by Knowledge E Publishing Services. ISSN 2413-0877. 2: 286-293.

Rajendran, S., Afari-Sefa, V., Bekunda, M., Dominick, I. and Lukumay, P.J. 2014. "Does Crop Diversity Contribute to Dietary Diversity?" Evidence from integration of vegetables into maize based farming systems in Tanzania. Contributed Discussion Paper at the 88th Annual Conference of the Agricultural Economics Society, Agro Paris Tech, Paris, France.

Razim, M.D.T.M. 2011. Genotype-environment interaction in pumpkin (*Cucurbita moschata*, Dutch ex poir). A Master of Science Thesis Bangabandhu Sheikh Mujibur Rahman Agricultural University, Gazipur.

Rhymer, J. M. and Simberloff, D. 1996. Extinction by hybridization and introgression. Annual Review of Ecology and Systematics, 27(1):83-109.

Schippers, R.R. 2000. African indigenous vegetables: An overview of the cultivated species. Agricultural and Rural Cooperation, p. 214. Natural Resources Institute/ACP-EU Technical Centre for International Cooperation. Chatham, UK.

Schmidt, L. H. 2000. Guide to handling of tropical and subtropical forest seed. Danida Forest Seed Centre.

Statistical Analysis System, Institute Inc. 1989. *SAS/STAT users guide*, Version 6, 4th Edition, Vol. 1. Cary, NC: SAS Institute Inc.

Su, H., Qu, L.J., He, K., Zhang. Z., Wang, J., Chen, Z. AND Gu, H. 2003. The Great Wall of China: a physical barrier to gene flow. Heredity, 90(3):212–219.

Swiderska, K. 2009. Protecting community rights over traditional knowledge: Implications of customary laws and practices. International Institute for Environment and Development, Endsleigh Street, London, WC1H ODD, UK.

Thies, E. 2000. Incentive measures appropriate to enhance the conservation and sustainable use of agrobiodiversity. GTZ, Eschborn, Germany.

USDA. 2006. "Can genetic diversity be influenced by nursery practices". In: Why we Care about Genetics Volume 10. National Forest Genetics Laboratory (NFGEL), Pacific Southwest Research Station, Placerville, and Genetic Resources Conservation Program, University of California, Davis, CA USA. http://www.fs.fed.us/psw/programs/nfgel/ or http://www.grcp.ucdavis.edu

Weltzien, E. and Fischbeck, G. 1990. Performance and variability of local barley landraces in near-eastern environments. Plant Breed. 104:58-67.

Wien, H.C., Stapleton, S.C., Maynard, D.N., McClurg, C. and Riggs, D. 2004. Flowering, sex expression, and fruiting of pumpkin (*Cucurbita* sp.) cultivars under various temperatures in greenhouse and distant field trials. HortScience, 39(2):239-242.

Wyenandt, A. 2006. Diagnosing and managing important pumpkin diseases in the home garden – Part 2. Rutgers Cooperative Research and Extension, (NJAES), Fact sheet, No. 357. Rutgers, the State University of New Jersey. New Brunswick.