International Journal of Scientific Research

http://journalijsr.com/ Vol. III, Issue 1, 2018

Food and Income Provision Influence Production of Pumpkins in Kakamega and Nyeri Counties of Kenya

Kiramana, J.K.[1] and Isutsa, D.K.[1,2]
[1]Chuka University, P. O. Box 109-60400, Chuka, Kenya
[1,2]Egerton University, P. O. Box 536-20115, Egerton, Kenya

Abstract

Pumpkin is an emerging important fruit-vegetable, although its potential remains unexploited in Kenya. This study aimed at enhancing conservation, preservation and production of naturalized pumpkins through characterisation of accessions and documentation of indigenous traditional knowledge influencing cultivation and utilization. An expedition in 2012 led to collection of 155 accessions belonging to Cucurbita moschata (Lam.) Poir.), with 70 from Kakamega and 85 from Nyeri. The variegated accessions were significantly (P<0.05) the most popular and highly utilized, compared to the exotic green-leafed ones. Significantly (P<0.05) more green-leafed accessions were collected in Nyeri, and variegated in Kakamega. They had significant (P<0.05) fruit shape and skin colour variation. Fruit-form ranged from ovate to globose or elliptical, and the predominant skin colour was dark to pale-green. Intercropping was significantly (P<0.05) the main cropping system. Food provision and income generation significantly (P<0.05) influenced consumption and cultivation of the pumpkins. Most variegated accessions were inherited from past generations and have become naturalized. The green-leafed accessions were introduced by farmers and other stakeholders. Fruits and leaves were significantly (P<0.05) utilized by farmers, compared to seeds and whole plants. The quality of fruits and leaves, cooking method and recipes were significantly (P>0.05) considered by farmers when selecting accessions to cultivate. These factors were significant (P>0.05) in sustaining genetic diversity and conservation. Interventions to preserve positive factors and overcome constraining ones should be promoted to enhance growing of naturalised pumpkin for health creation and income generation.

Key words: Accession, Morphological characterisation, Green-leafed, Variegated plant

INTRODUCTION

Pumpkins belong to the family Cucurbitaceae (Jeffrey, 1990) and originated from Central and South America (Grubben and Chigumira, 2004). Naturalized traditional landraces are highly adapted to specific cultivation conditions (Marilene *et al.,* 2012). Pumpkins are an integral part of agricultural systems (Ngugi *et al.,* 2007) and have great prospects for food product development, but their potential is not adequately appreciated and fully exploited in Kenya. Consequently, they are referred to as “orphaned”, “minor”, “neglected”, “under-utilized”, “under-developed” or “under-exploited crop species”. The “minor” depiction arises from the small commercial value of produce and trade, while “neglected” depicts the little research and development attention bestowed on pumpkins. Majority of them are inadequately characterized and generally have very little scientific information known about them. Subsequently, they have remained “under-utilized” in national development (Naluwairo, 2011).

The rich genetic diversity in local pumpkin species could provide important basis for enhancing food security and sustainable development (Porth and El-kassaby, 2014). The local species are very important in repository of genes for drought and pest resistance (Marilene *et al*., 2012). Rural farmers grow their own landraces, but improved cultivars have emerged onto the local markets (Grubben and Chigumira, 2004). Consequently, the genetic variation in local landraces, once considered unlimited, is fast-eroding, as traditional, naturalised and wild relatives of cultivated species are being replaced or destroyed by exotic cultivars being introduced from foreign countries (Ricciardi and Filippetti, 2000; Tapia and Estrella, 2001).

The use of imported hybrid seeds of narrow genetic base in pursuit of high profits is endangering the local genetic variability (Marilene *et al*., 2012; Ricciardi and Filippetti, 2000; Tapia and Estrella, 2001). The local landraces are vanishing from their original growing regions and are faced with eminent danger of genetic erosion or extinction (Engels and Visser, 2003). Availability of useful genes determines the success of plant breeders in developing varieties with specific characteristics (Engle, 1994). Considering the genetic erosion risk facing local landraces in Kenya, the present study concentrated on pumpkin germplasm and indigenous knowledge collection, characterisation, conservation and documentation (Marilene *et al*., 2012).

METHODOLOGY

Germplasm Collection

Pumpkin germplasm was collected in Kakamega and Nyeri Regional Service Units (RSUs). The expedition took ten days from 26th - 30th March, and 16th - 20th April, 2012 in Kakamega and Nyeri RSUs, respectively. Ten sub-counties with two divisions each and various locations, sub-locations and villages were visited. Initial information on pumpkin germplasm rich locations in each RSU was obtained from the former provincial director of agriculture (PDA) offices, based on crop statistics reports. Bottom up approach, from farmers, location manned by the agriculture field extension officers (FEOs), division, subcounty and provincial levels, was also used to avail factual and credible information that was used to identify pumpkin rich locations.

Participatory rural appraisal techniques which incorporated diagnostic and formal surveys, key informant interviews and checklists (Friss-Hansen and Bhuwon, 2000), hastened and facilitated discussions. Key informants were selected with the assistance of FEOs. Passport data and collection information were gathered using cucurbit IPGRI descriptors (IPGRI, 2003). The IPGRI collection descriptors were used to obtain specific information on practices, ethno-botanic information, opportunities for production and utilization of pumpkins. Farmers were identified through purposive sampling based on their interest and constraints that needed to be addressed. Farmers growing pumpkins were used to identify traditional landraces and those introduced in the areas. The farmers generally described past and present-day landraces and the differences from those grown in other villages, locations, divisions and/or places. The description helped tap ethno-botanic information important in separating more or less "pure" or original landraces from material where a lot of introgression and hybridization had taken place in recent years.

Either seeds or fruits were collected, depending on what was available with the farmers. Fruits were cut across to extract seeds, which were washed and air-dried under room temperature. The seeds were packaged in polythene bags to ease transportation. The collected germplasm was tentatively labeled with date of collection, location and code number, based on the itinerary of collection. The seeds were further dried to 14% moisture content, sorted, repackaged, and re-labeled to include the funding organization, collaborating institution, RSU, collector's initials, and accession number, giving KAPAP/CU/KK/JKK/1-70 for Kakamega accessions, and KAPAP/CU/NY/JKK/71-155 for Nyeri accessions.

Sampling Strategy and Techniques

Purposive sampling was used with a focus of capturing maximum pumpkin diversity in all agro-ecologies within and among the subcounties. The sampling involved single-day visit, fine-grid intensive and species-specific (*Cucurbita moschata* (Lam) Poir.) exercise in each subcounty. The one-day visit and timing of collection did not miss the diversity, because pumpkin is an annual crop grown and stored by farmers in the target areas. Therefore, the desired germplasm accessions were collected at a reduced cost and time.

Data Recording and Analysis

A global positioning system receiver (Garmin eTrex Summit, 2000) was used to determine geographic coordinates. 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 to compare the expected versus observed frequencies at P = 0.05, using the SAS software.

RESULTS AND DISCUSSION

Germplasm Collection

A total of 155 accessions, with 70 from Kakamega and 85 from Nyeri were collected in agro-ecological zones with varying altitudes, latitudes and longitudes (Table 1). Soil types were sandy, clay and red-loams in Kakamega, and red and red-clay loams in Nyeri (Tables 2 and 3). Many accessions were obtained in Kakamega South and Mathira East, and few in Butere and Mathira West sub-counties (Tables 1, 2 and 3).

Table 1: Germplasm collection agro-ecological zones, altitudes, latitudes and longitudes

Accession code	Region	AEZs	Altitude (L-H)	Latitude (L-H)	Longitude (L-H)	Total
KAPAP/CU/ JKK/ KK-1-14	KK Central	UM 0, UM 1, LM 1,LM 2	1441-1547 M	00^0 15' 42"N - 00^0 18' 04"N,	034^0 41' 20"E -034^0 45' 51"E	14
KAPAP/CU/	KK East	UM 0, LM	1522 -	00^0 13'	034^0 49'	16

JKK/ KK-15-30		1, LM 2	1562 M	03"N - 00^0 16' 18"N	47"E -034^0 50' 54"E	
KAPAP/CU/ JKK/ KK-31-53	KK South	UM 1, LM 1, LM 2, LM 3	1478-1534 M	00^0 08' 21"N -00^0 12' 52"N,	034^0 39' 41"E -034^0 45' 08"E	23
KAPAP/CU/ JKK/ KK-54-57	Butere	LM 1	1383-1417 M	00^0 11' 15"N - 00^0 13' 42"N,	034^0 31' 52"E -034^0 32' 42"E	4
KAPAP/CU/ JKK/ KK-58-70	Khwisero	LM 1	1466-1556 M	00^0 07' 54"N - 00^0 18' 14"N	034^0 31' 50"E -034^0 45' 18"E	13
KAPAP/CU/ JKK/ NY-71-97	Mathira East	LH 1-3, UM 1-3, UH 0-UH 1	1687-1843 M	00^0 26' 38"S - 00^0 31' 35"S,	037^0 06' 59"E -037^0 08' 42"E	27
KAPAP/CU/ JKK/ NY-98-108	Mathira West	UM 2-4, LH 2-3,	1649-1817 M	00^0 24' 35"S -00^0 27' 27"S,	037^0 02' 58"E -037^0 04' 37"E	11
KAPAP/CU/ JKK/ NY-109-129	Nyeri Central	UM 2-4, LH 1-3	1767-1858 M	00^0 26' 13"S - 00^0 27' 47"S,	037^0 57' 07"E -037^0 57' 09"E	21
KAPAP/CU/ JKK/ NY-130-143	Tetu	UH 1, UM 1-3, LH 1-2	1772-2128 M	00^0 25' 08"S - 00^0 30' 44"S,	036^0 52' 55"E -037^0 02' 38"E	14
KAPAP/CU/ JKK/ NY-144-155	Nyeri South	UH 1, LH 1, UM 1-2	1870-1950 M	00^0 34' 09"S - 00^0 35' 35"S,	036^0 54' 53"E -036^0 55' 25"E	12

KK =Kakamega**, NY=**Nyeri**, UM** =upper midland, **LM** =lower midland, **LH** = lower highland, **UH** = upper highland, and **0** =Per-humid, **1** =Humid, **2** =Sub-humid, **3** =Semi-humid, **4** =Transitional. Agro-ecological zones (**AEZs**), **L-H** = Lowest to highest, **LH** = 1-4, **UM**1-5 and **LM**3-4 occur at descending altitudes, The zones, **UH** 2, 3 and **LH** 2, 3, 4, 5 indicate decreasing rainfall already in higher altitudes.

Table 2: Germplasm collection target areas in Kakamega

Acc Code	Sub-county	Ward	Location	Sub-location	Village	Soil types
KK-1	Kakamega	Lurambi	Central	Shinyunz	Murumb	Sandy

	Central		Butsotso	u	a	loams
KK-2 to 4	Kakamega Central	Lurambi	Central Butsotso	Shinyunzu	Murumba	Sandy loams
KK-4 to 5	Kakamega Central	Lurambi	Central Butsotso	Shibuli	Ebinzo	Sandy loams
KK-6	Kakamega Central	Lurambi	Central Butsotso	Shibuli	Emosiomi	Sandy loams
KK-7 to 9	Kakamega Central	Lurambi	Central Butsotso	Shibuli	Emosiomi	Sandy loams
KK-10	Kakamega Central	Lurambi	Central Butsotso	Shinyunzu	Murumba	Sandy loams
KK-11 to 12	Kakamega Central	Municipality	Shieywe	Sichirayi	Highlands	Sandy loams
KK-13	Kakamega Central	Municipality	Shieywe	Sichirayi	Shihambi	Sandy loams
KK-14	Kakamega Central	Municipality	Bukhungu	Sirere	Lutunyi	Sandy loams
KK-15 to 22	Kakamega East	Shinyalu	Shibuye	Mukhungu	Matsu	Clay loams
KK-23 to 24	Kakamega East	Shinyalu	Shibuye	Mukhungu	Mukhungu	Clay loams
KK-25 to 26	Kakamega East	Shinyalu	Muranda	Mukulusu	Shemiloli	Clay loams
KK-27 to 30	Kakamega East	Shinyalu	Muranda	Mukulusu	Isasala	Clay loams
KK-31	Kakamega South	Ikolomani North	Shirumba	Shivakala	Inyenyi	Sandy loams
KK-32 to 34	Kakamega South	Ikolomani North	Shirumba	Shivakala	Imasaba	Sandy loams
KK-35 to 36	Kakamega South	Ikolomani North	Shirumba	Shivakala	Ichina	Sandy loams
KK-37	Kakamega South	Ikolomani North	Isulu	Lunenele	Lukanji	Sandy loams
KK-38 to 39	Kakamega South	Ikolomani North	Shisere	Mutaho	Shisende	Sandy loams
KK-40 to 41	Kakamega South	Ikolomani South	Shukumu	Shabwali	Truvini	Red loams
KK-42	Kakamega South	Ikolomani South	Shukumu	Madivini	Shambole	Red loams
KK-43 to 47	Kakamega South	Ikolomani South	Shukumu	Madivini	Shambole	Red loams
KK-48 to 49	Kakamega South	Ikolomani South	Shukumu	Madivini	Shambole	Red loams
KK-50	Kakamega South	Ikolomani South	Shukumu	Madivini	Shambole	Red loams

KK-51	Kakamega South	Ikolomani South	Shukumu	Madivini	Shambole	Red loams
KK-52 to 53	Kakamega South	Ikolomani South	Iguhu	Makhokho	Makhokho	Red loams
KK-54	Butere	Butere	Marenyo	Buboko	Munges e	Clay loams
KK-55 to 57	Butere	Lunza	West Marama	Buchenya	Shibanga	Clay loams
KK-58 to 62	Khwisero	Khwisero East	Kisa North	Mundobilwa	Mushinaka	Red loams
KK-63 to 65	Khwisero	Khwisero East	Kisa South	Emalindi	Emalindi	Red loams
KK-66 to 68	Khwisero	Khwisero West	Shirombe	Ebuhala	Khusokuti	Sandy loams
KK-69 to 70	Yala/Khwisero	Yala/Khwisero	Yala Township	Anyiko	Tatro	Sandy loams
NY-71 to 72	Mathira East	Magutu	Ragati	Mungi	Kafugi	Red loams

Table 3: Germplasm collection target areas in Nyeri

Acc Code	Sub-county	Ward	Location	Sub-location	Village	Soil types
NY-71 to 72	Mathira East	Magutu	Ragati	Mungi	Kafugi	Red loams
NY-73 to 76	Mathira East	Magutu	Ishuha	Ishuha	Gathumbi	Red loams
NY-77 to 78	Mathira East	Magutu	Ishuha	Ishuha	Gathumbi	Red loams
NY-79	Mathira East	Magutu	Gathehu	Gathehu	Kahuro-ini	Red loams
NY-80	Mathira East	Magutu	Gathehu	Gathehu	Gatambi	Red loams
NY-81 to 83	Mathira East	Konyo	Gachuku	Gachuku	Kiamabara	Red loams
NY-84 to 86	Mathira East	Konyo	Gachuku	Gachuku	Kiamabara	Red loams
NY-87 to 90	Mathira East	Konyo	Gachuku	Gachuku	Kiamabara	Red loams
NY-91 to 93	Mathira East	Konyo	Gachuku	Gachuku	Kiamabara	Red loams
NY-94 to 95	Mathira East	Konyo	Gakuyu	Gakuyu	Dima-ini	Red loams
NY-96 to 97	Mathira East	Konyo	Gakuyu	Gakuyu	Dima-ini	Red loams
NY-98 to	Mathira	Ngorano	Ngorano	Karuthi	Ngorano	Red

99	West Mathira					loams
NY-100	West Mathira	Ngorano	Ngorano	Karuthi	Ngorano	Red loams
NY-101	West Mathira	Ngorano	Ngorano	Karuthi	Ngorano	Red loams
NY-102	West Mathira	Ngorano	Ngorano	Karuthi	Kiambugu	Red loams
NY-103	West Mathira	Kirimukuyu	Kirimukuyu	Ngaine	Kirigithi	Red loams
NY-104	West Mathira	Kirimukuyu	Kirimukuyu	Ngaine	Kirigithi	Red loams
NY-105 to 107	West Mathira	Kirimukuyu	Kirimukuyu	Ngaine	Rukandu	Red loams
NY-108	West Mathira	Kirimukuyu	Kirimukuyu	Ngaine	Rukandu	Red loams
NY-109	Nyeri Central	West Municipality	Kamakwa	Kamakwa	Ngangarithi	Red clay loams
NY-110 to 113	Nyeri Central	Central Municipality	Ruring'u	Ruring'u	Ruring'u	Red clay loams
NY-114 to 121	Nyeri Central	Central Municipality	Ruring'u	Riamukurwe	Githima	Red clay loams
NY-122 to 124	Nyeri Central	Central Municipality	Ruring'u	Ithenguri	Ithenguri	Red clay loams
NY-125	Nyeri Central	Central Municipality	Ruring'u	Gatitu	Gatitu	Red clay loams
NY-126	Nyeri Central	West Municipality	Kamoko	Kamoko	Ngangarithi	Red clay loams
NY-127	Nyeri Central	West Municipality	Kamoko	Karia	Ciara-ini	Red clay loams
NY-128 to 129	Nyeri Central	West Municipality	Kamoko	Kamoko	Ciara-ini	Red clay loams
NY-130	Tetu	Tetu West	Tetu	Kigogo-ini	Kigogo-ini	Red loams
NY-131	Tetu	Tetu West	Tetu	Kigogo-ini	Kigogo-ini	Red loams
NY-132	Tetu	Tetu West	Mahoya	Ihururu	Rutura	Red loams
NY-133 to 134	Tetu	Tetu West	Mahoya	Ihururu	Rutura	Red loams
NY-135	Tetu	Tetu West	Mahoya	Ihururu	Wamicuri	Red loams
NY-136	Tetu	Tetu East	Gaaki	Gatheithi	Gathugu	Red loams
NY-137 to 138	Tetu	Tetu East	Gaaki	Gatheithi	Gathugu	Red loams

NY-139 to 140	Tetu	Tetu East	Gaaki	Gatheithi	Gathugu	Red loams
NY-141	Tetu	Tetu East	Aguthi	Ithaga-ini	Ithekahuno	Red loams
NY-142 to 143	Tetu	Tetu East	Aguthi	Ithaga-ini	Ithekahuno	Red loams
NY-144	Nyeri South	Othaya South	Chinga South	Mumbu-ini	Kahutiri	Red loams
NY-145 to 155	Nyeri South	Othaya Central	Iria-ini	Gitundu	Gitundu	Red loams

RSU-regional service units; KK-Kakamega; NY-Nyeri; ACC-accession

Type of Germplasm Collected

Fruit germplasm and variegated accessions were collected in Kakamega, while seed germplasm and green-leafed accessions were collected in Nyeri (Figure 1).

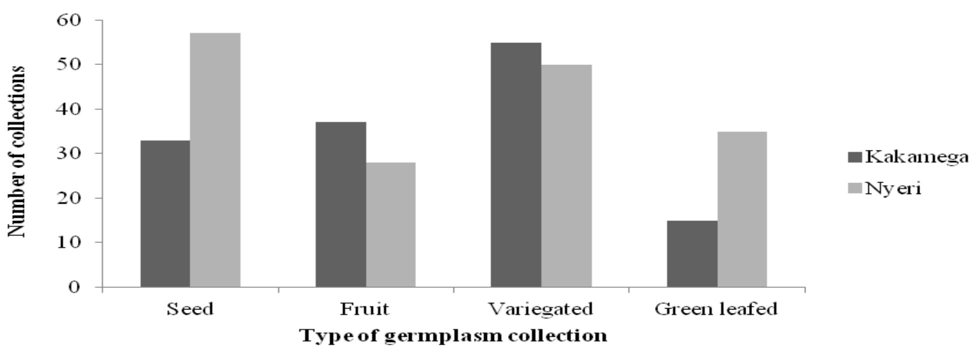

Figure 2: Type of germplasm collected in Kakamega and Nyeri RSUs

The collected seeds and fruits, variegated and green-leafed accessions differed significantly ($P<0.05$) among the sub-counties. Many collected accessions were seeds in Mathira East, fruits and variegated in Kakamega South, and green-leafed in Kakamega East. The seeds and green-leafed accessions collected varied significantly ($P<0.05$) in Kakamega, but the fruits and variegated accessions did not vary significantly ($P>0.05$) in Nyeri (Table 4).

Table 4: Frequency of seed, fruit, and variegated and green-leafed accession collections

	Seed	**Fruit**	**Variegated**	**Green leafed**
Sub Counties	Obs N	Obs N	Obs N	Obs N
Kakamega Central	7	7	13	1
Kakamega East	9	7	6	10
Kakamega South	9	14	21	2
Butere	2	2	3	1
Khwisero	6	7	12	1

Mathira East	20	7	19	8
Mathira East	9	2	8	3
Nyeri Central	19	2	14	7
Tetu	9	5	6	8
Nyeri South	0	12	3	9
Total	90	65	105	50
Exp N	10	6.5	10.5	5.0
χ^2	27.4	23.2	34.5	24.8
df	8	9	9	9
***P*-value**	0.001	0.006	0.000	0.003

Hardiness of pumpkin germplasm

Occurrence of pumpkin germplasm was significantly ($P<0.05$) abundant and frequent in Kakamega, and occasional and rare, but not significantly ($P>0.05$) in Nyeri (Table 5).

Table 5: Frequency of germplasm occurrence in RSUs

	Abundant	Frequent	Occasional	Rare
RSU	Obs N	Obs N	Obs N	Obs N
Kakamega	40	12	3	15
Nyeri	18	39	1	27
Total	58	51	4	42
Exp N	29.0	25.5	2	21.0
χ^2	8.345	14.294	1.000	3.429
df	1	1	1	1
***P*-value**	0.004	0.000	0.317	0.064

Diversity of collected germplasm

The shape and predominant rind colour of collected fruits of accessions showed significant ($P<0.05$) variation. The common shape was globular, and the predominant fruit skin colour was dark-green (Table 6).

Table 6: Frequency of qualitative characters of collected fruits among the accessions

Fruit shape	**%**	**Obs. N**	**Exp N**	**χ^2**	**df**	***P*-value**
Ovate	18	12	9.3	15.9	6	0.014
Globular/Round	28	18	9.3			
Elliptical	17	11	9.3			
Pyriform / pearlike	9	6	9.3			
Flattened	9	6	9.3			
Acorn	14	9	9.3			
Elongated	5	3	9.3			
Total		65				
Predominant fruit rind colour	**%**	**Obs. N**	**Exp N**	**χ^2**	**df**	***P*-value**

Cream	6	4	8.1	53.3	7	0.000
Pale-green	12	8	8.1			
Green	25	16	8.1			
Dark-green	37	24	8.1			
Blackish-green	8	5	8.1			
Light-yellow	3	2	8.1			
Orange	3	2	8.1			
Grey	6	4	8.1			
Total		65				

Pumpkin Production Trends

The survey revealed the number of female and male farmers growing pumpkins were equal in Kakamega, while more females than the males were found in Nyeri. Generally more females than male were involved in production of pumpkins in Kakamega and Nyeri Counties (Figure 2).

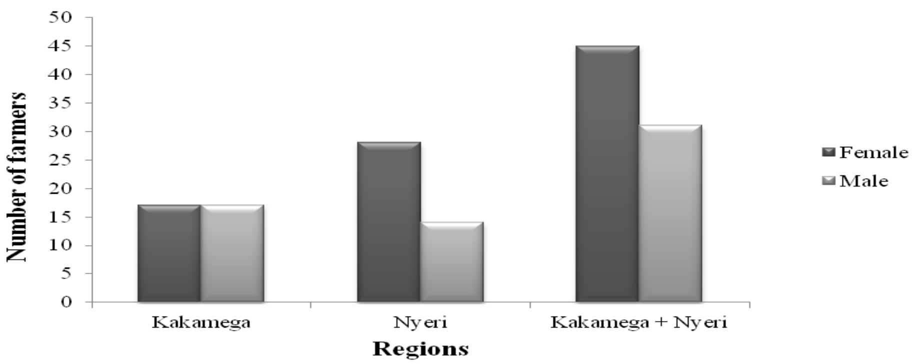

Figure 2: Proportion of female and male farmers producing pumpkins in Kakamega and Nyeri RSUs

The cropping pattern for pumpkins significantly ($P<0.05$) differed among the farmers. Intercropping pumpkins with other main crops was practiced by most of the farmers. Mono-cropping and both mono-cropping and intercropping was practiced by only a few. The growing conditions of the accessions showed significant ($P<0.05$) variation. Most of the accessions were grown under upland, but a few in atoll and wetland conditions. They were grown using atoll pits by 1.3% of the farmers, 13.3% volunteer crops, and 85.3% using manure, fertile land, but no other special treatment. The farm sizes were significantly ($P<0.05$) different, with majority of being below one hectare (Table 7).

Table 7: Frequency of cropping systems, farm size holdings and growing conditions

Cropping systems	**%**	**Obs. N**	**Exp N**	**χ^2**	**df**	***P*-value**
Intercropping	95	72	25.3	1.29	2	0.000
Mono-cropping	4	3	25.3			
Intercropping & Mono-cropping	1	1	25.3			
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	10.9			
Three quarter ha	12	9	10.9			
One ha	20	15	10.9			
One half ha	11	8	10.9			
Two ha	9	7	10.9			
Above two ha	5	4	10.9			
Total		**76**				
Growing conditions	**%**	**Obs. N**	**Exp N**	χ^2	**df**	***P*-value**
Uplands	80	124	31.0	354.3	4	0.000
Slopes	12	18	31.0			
Lowland	6	9	31.0			
Atoll pits	1	2	31.0			
Wetlands	1	2	31.0			
Total		**155**				

Pumpkin Utilization Trends

The leaves, fruits, seeds and whole plants utilization of the accessions differed significantly ($P<0.05$). The leaves of most of the accessions were utilized weekly and fruits occasionally (Table 8). Fruit and leaf use, and taste of the accessions were significantly ($P<0.05$) different. The taste of both leaves and fruits was good, with fruits being more utilized than leaves for most of the accessions (Figure 3).

Table 8: Utilization frequency of pumpkin parts among the accessions

	Daily	**Weekly**	**Occasional**	**Rarely used**	**Not used**
Characters	Obs N	Obs N	Obs N	Obs N	Obs N
Leaves	36	100	19	0	0
Fruits	4	61	86	4	0
Seeds	0	1	42	0	112
Whole plant	0	8	0	0	147
Total	40	170	147	4	259
Exp N	20.0	42.5	49.0	0	129.5
χ^2	25.6	154.4	47.3	0	4.73
df	1	3	2	0	1
***P*-value**	0.000	0.000	0.000	0	0.03

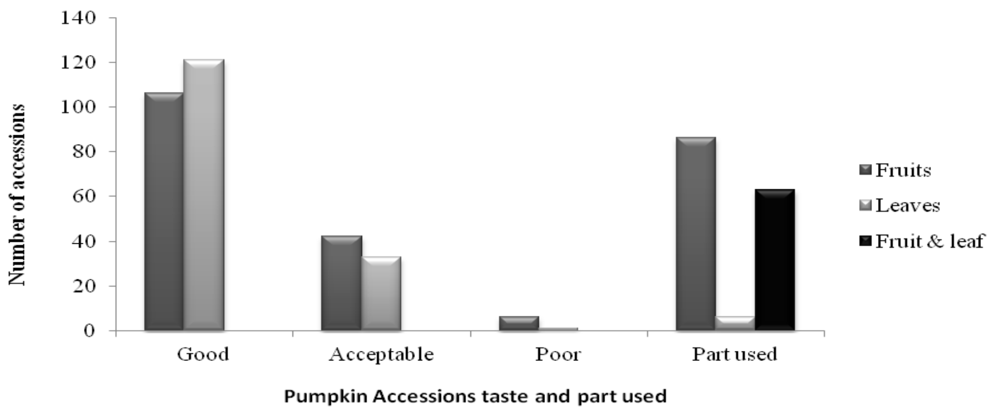

Figure 3: The taste and utilization of pumpkin parts among the accessions

Cooking Styles and Recipes of Pumpkins

Cooking styles and recipes for the seeds, fruits and leaves differed significantly (*P* <0.05) among the households surveyed. Most of the farmers did not use pumpkin seeds, and had no recipe for fruits and leaves. Some of the cooking styles and recipes used by the farmers included mixing of pumpkin seeds with cereals and grinding into flour, cooking leaves and fruits mixed with potatoes to make mashed food, or cooking separately to accompany other meals (Table 9).

Table 9: Frequency of cooking styles and recipes among the farmers

Seed	**%**	**Obs N**	**Fruits and leaves**	**%**	**Obs N**
Consumed raw	1	1	Accompany other foods	20	15
Roasted	5	4	Mixed + other foods	13	10
Fried	3	2	Substitute potatoes to make githeri	3	3
Mixed + simsim & ground	4	3	Mixed + potatoes to make mukimo	20	15
Mixed + grains & ground	12	9	Fruits and wheat flour mixed	9	7
Mixed + dried fruits & ground	3	2	Fruits cooked in a rice mixture	2	1
Seed not used	72	55	No recipes	33	25
Total		76	**Total**		76
Exp N		10.9	**Exp N**		10.9
χ^2		213.2	**χ^2**		37.7
df		6	**df**		6
***P*-value**		0.00	***P*-value**		0.00

Popularity and Commercialization of Pumpkins

Popularity and commercialization of accessions varied significantly (*P* <0.05) among the farmers in Kakamega and Nyeri. Most of the accessions were popular and majority of the farmers sold either fruits or leaves (Table 10). Pumpkin leaves retailed at Ksh 20 per bundle of five leaves in the local market. Fruits were sold at Ksh 20 to Ksh 100 in Kakamega, and Ksh 20 to Ksh 250 in Nyeri. Visual judgment, but no standard measurement, was used to determine pumpkin fruit prices by the buyers and sellers. Fruits were sold in local markets and those beyond Kenya.

Table 10: Frequency of popularity and commercialization of pumpkins

Popularity of accessions	%	Obs. N	**Market information**	%	Obs. N
Yes	70	109	Selling of pumpkins	63	48
No	30	46	No selling of pumpkins	37	28
Total		155	**Total**		76
Exp. N		77.5	**Exp. N**		38.0
χ^2		25.6	χ^2		5.263
df		1	**df**		1
***P*-value**		0.000	***P*-value**		0.022

Purpose of Growing Pumpkins

The purpose of growing pumpkins was significantly (P <0.05) for food provision and income generation. Food provision and income generation were the major driving forces that influenced pumpkin utilization and cultivation by majority of the farmers (Table 11). Very few farmers grew pumpkins for other reasons. The past and present pumpkins showed significant (P<0.05) differences in fruit characters, with fruit shape portraying much variation according to majority of the farmers (Table 11). All the farmers surveyed reported no observed differences among pumpkins grown in sub-counties surveyed and other villages within and beyond Kakamega and Nyeri Counties.

Table 11: Frequency of reasons for pumpkin growing, and their past and present differences

Reasons for growing pumpkin	**%**	**Obs. N**	**Exp N**	χ^2	**df**	***P*-value**
Food	28	21	9.5	162.1	7	0.000
Food and income	55	42	9.5			
Fruits	2	1	9.5			
Foliage	1	1	9.5			
Fruits and foliage	9	7	9.5			
Supply to schools	1	1	9.5			
Food during drought	3	2	9.5			
Food, income and animal feed	1	1	9.5			
Total		76				
Differences in past and present landraces	**%**	**Obs. N**	**Exp N**	χ^2	**df**	***P*-value**
Fruit size	22	17	12.7	45.6	5	0.000

Shape	39	30	12.7
Taste	23	17	12.7
Flesh	4	3	12.7
Flesh thickness	9	7	12.7
Fruit surface	3	2	12.7
Total		76	

DISCUSSION

Germplasm Collection

Pumpkin germplasm was collected in varied agro-ecological zones, altitudes, latitudes and longitudes. The high variation found in pumpkins provides rich genetic diversity for cultivation in diverse environments (Awan *et al*., 2013). In the present study, neither agro-ecology nor geographic position affected the number of germplasm collected from the sub-counties. Studies by Sun *et al*. (2013) reported negative linear relationship between plant abundance and geographic positions due to variation in climatic, soil and micro-climatic conditions. The collected germplasm were landraces cultivated for many generations. However, some of the local species and exotic green-leafed cultivars were recent introductions brought in by farmers and other stakeholders. The collected local landraces were not any different from those found in other villages within and beyond Kakamega and Nyeri. Culture being an integral part of livelihoods, participation of the community, coupled with on-farm conservation, is central to agricultural biodiversity status (CIP-UPWARD, 2003). The community socio-cultural values safeguard diversity (Ondigi *et al*., 2008), and provide important aspects of cultural identity (Howard, 2006). Beltran (2000) reported contributions made by elders in maintaining local landraces through traditional sustainable-use practices and culture-based respect for nature.

Type of Germplasm

In the present expedition, both local pumpkin species and exotic cultivars were collected. The exotic cultivars were mostly found in Nyeri, and in subcounties where non-governmental organizations had set up agricultural projects. Introducing exotic cultivars into the local environment increases their invasive colonization opportunities. They affect the local ecology through competitive exclusion, extirpation and loss of biological diversity (Holzman *et al.*, 2009; Rhymer and Simberloff, 1996) through genetic pollution, hybridization, introgression and swamping (Mooney and Cleland, 2001; Aubry *et al*., 2005), homogenization (Aubry *et al*., 2005) or replacement (Ngugi *et al.,* 2007; Aubry *et al*., 2005) of local species numerical and/or fitness advantage (Aubry *et al*., 2005). The exotic cultivars can also affect the magnitude of genetic diversity through diffusion and niche displacement of local landraces (IBC, 2007). Pumpkin germplasm was abundant and frequent in the surveyed sub-counties. This was attributed to a sizeable number of farmers planting pumpkins every year. Germplasm was occasional in some subcounties where farmers planted them episodically, or rare if only a few farmers planted after a long period. The accessions that were abundant or frequent were considered at little risk, and those that were occasional or rare were considered at high risk to genetic erosion.

Diversity of Germplasm

The collected fruit germplasm portrayed great shape and skin colour variation. Fruit characters are crucial and essential in the genetic improvement of pumpkin (Nwofia *et al*., 2012). Studies by Onyishi *et al*. (2013) reported high variation in cucurbit fruit shape and other qualitative traits. The high variation of fruits was due to genetic and cultivar differences. During the survey, farmers reported differences between the past and present pumpkin landraces. They said that the present landraces had smaller fruits, were less sweet, flesh was soft and less thick, and fruit surfaces were rough. Some of these differences were attributed to the changes that have occurred in the environment over the years. Razim (2011) stated that the response of genotypes in different locations, years or seasons, depends on environmental interaction. Fruit characters such as yields that are polygenic in nature are influenced by environmental factors (Pandey *et al.,* 2008). Maynard (2007) and Balkaya *et al*. (2011) reported that fruit sizes are influenced by genetics, environment and plant conditions. Conditions that reduce the amount of assimilate available and the water supply decreases the size of individual fruit and soluble solids (Maynard, 2007). The differences were also attributed to limited land resource and intensive cultivation of lands by farmers (Oloyede *et al*., 2013a). Most of the present soils are eroded with no fertilizer addition, or crop rotation important to maintain and regenerate soil fertility. Cultivation is determined by short-term financial gains, which result in neglecting of agricultural systems diversity (Davari *et al*., 2013). Studies by Oloyode *et al*. (2013) reported increase in fruit length, circumference, fresh weight and dry matter as fertilizer application increased. Competition of pumpkins with intercropped main crops also contributed to decreasing fruit size and quality. Momirovic *et al*. (2015) reported significant high yields in sole cropped pumpkins than in intercropped pumpkins. Intercropping reduces yields when interspecific and intraspecific competition is high in the same environment (Maynard, 2007; Momirovic *et al*., 2015).

Ethno-Botanic Information

Pumpkin production

In the survey area, more women than men were involved in pumpkin production. This was contrary to reports by Ondigi *et al*. (2008) that majority of the families cultivating pumpkin were headed by men. Socio-economic characteristics such as gender and the occupation of household head influence production. For instance, males doing farming as their main occupation influence the crop to be grown (Masayi and Netondo, 2014). In the present study, men considered pumpkin a crop of low value. It was grown in areas like kitchen waste dumping sites, former cattle sheds and demolished mud huts. Zinash *et al*. (2013) observed pumpkin production near fences, creeping on houses, growing on marginal or waste land, decaying hay and heap of cow dung. These areas did not interfere with land for high value crops (Masayi and Netondo, 2014). Farmers living near towns practiced kitchen gardening due to small land parcels. The kitchen gardens were mostly managed by women, who were mostly the bread winners and engaged in feeding the households to improve their welfare and that of children (Masterson, 2007). These factors and many others could have consigned pumpkin production in the hands of women (Ondigi *et al*., 2008). On the other hand, men who are used to controlling increased cash income were less likely to engage in less profitable pumpkin farming (Kiriti and Tisdell, 2003).

Pumpkins were mainly grown as intercrops, with sole or both intercropping and sole cropping being practiced rarely. Ndoro *et al*. (2007) observed most pumpkins being intercropped and only a few were planted as sole crops. Zinash *et al*. (2013) reported that traditional pumpkins were intercropped with cereals. Studies by Agbagwa *et al.,* (2007) observed pumpkins grown in arable land and warm areas free from frost. Farm size owned by most of the farmers was below one hectare. Place *et al.* (2006) reported average pumpkin farm sizes between 0.5 and 2 hectares. Increased population pressure and reliance on farming as a livelihood has reduced the farm sizes (Maina *et al*., 2010). Farmers designate only very small portions of land (Ondigi *et al*., 2008) for pumpkin production, despite its cultivation requiring large area (Oloyede *et al*., 2013b). This has increased pumpkin isolation, inbreeding and loss of genetic diversity. Thus, reproductive success, biological diversity and species persistence is threatened (David *et al*., 2008).

Pumpkins were mostly planted for food and income provision by the farmers surveyed (Onyango and Onyango, 2005). This trend has been necessitated by reduction in land sizes, which has prompted farmers to select enterprises that maximize income and output on available land (Maina *et al*., 2010). Accessions planted for both food and income are at a less risk of erosion or extinction, because they are more likely to be conserved and prevented from disuse due to their economic and nutritional values (Onyango and Onyango, 2005). However, farmers are likely to specialize in planting few varieties demanded by the market, leading to lowering of the level of diversity and increasing uniformity of crop varieties conserved on-farm (Irungu *et al*., 2011). The local accessions were more popular among the farmers than exotic cultivars. Popularity of a species plays an important role in conservation and maintenance of diversity, but increased demand of certain species could lead to loss of on-farm biodiversity (Irungu *et al*., 2011).

The popularity of local accessions was due to their cultural identity in the communities and their adaptation and tolerance to both biotic and abiotic factors. These factors enhance local species cultural enrichment, biodiversity, conservation and public value through continued production and use (Irungu *et al.,* 2011). Maarten van (2013) reported that local landraces contain traits such as pest resistance, abiotic stress tolerance, and display traits that meet present and future needs. Very few farmers in the surveyed area had planted exotic green-leafed accessions. This was attributed to change of attitude towards local landraces, because improved cultivars had not proved to be superior in marginal environments with specific socio-economic conditions (Weltzien and Fischbeck, 1990). Mwaura (2004) reported a paradigm shift from exotic cultivars and resurgence of demand for local pumpkins, necessitated by the ability of local pumpkins to tolerate drought, market availability, and awareness by urban and peri-urban consumers on their health benefits and medicinal values. Pumpkin markets were occasional and offered low prices in Kakamega. The region has high potential for accessing markets, but actual commercialization of pumpkins was low (Place *et al*., 2006). The demand for pumpkin fruits and leaves was high in Nyeri. This was attributed to active marketing of pumpkins, which encouraged grow into commercial enterprise (Place *et al*., 2006). Irungu *et al*. (2011) reported increased commercialization of pumpkin leaves within Nairobi and its outskirts. Provision of markets for local pumpkins can be used to enhance on-farm biodiversity conservation. This would contribute to food security, source of livelihood and essential nutrients, because pumpkins have social, economic and health benefits (Irungu *et al*., 2011).

Pumpkin utilization

In the present study, pumpkin fruits, leaves, seeds and whole plants were used variedly (Ahamed *et al*., 2011). Munisse *et al*. (2011) stated that pumpkins were multipurpose and served an important role of enhancing food security and nutrition. Local, variegated accession fruits and leaves were utilized by majority of the farmers, who rarely used seeds and green-leafed accessions. These results showed that pumpkins in Kenya have not been fully utilized (Ngugi *et al.,* 2007). Some pumpkin accessions had wide range of uses and their cultivation was sustained for long. This helped maintain their genetic diversity and also conservation. Other accessions were underutilized, which placed them at high risk of genetic erosion or extinction (Davari *et al*., 2013). The taste of fruits and leaves in most of the accessions was rated to be good by farmers. The accessions that had fruits with sweet and hard flesh after cooking were said to be of good taste, those with semi-hard/soft/watery flesh were said to be of moderately acceptable taste, and those with watery flesh and no sweet were said to be of poor taste. Soft and sweet-leafed accessions were rated to be of good taste, soft and tasteless accessions were rated to be acceptable, and fibrous, prickly and tasteless leaves were rated to be of poor taste. The accessions of good taste are more likely to be maintained and conserved. Careful selection of accessions with taste and texture that make good food result in genetic diversity of relatively few plants remaining for food and agricultural use. These accessions underpin food security and provide insurance against future threats and ecological changes (Nakhauka, 2009).

Boiling was the most common method used to cook pumpkin fruits and leaves. Seeds were roasted, eaten raw or ground into flour after mixing with cereals. The communities in the survey area had their own food habits and dietary patterns, inherited from previous generations, as influenced by culture (Oniang'o *et al*., 2003). Some of the recipes found in the communities surveyed included mixing pumpkin seeds with simsim (*Sesamum indicum* L.), then roasting and consuming; chopping hard fruits into small pieces then cooking in a mixture of rice; eating fruits and leaves together with other foods; grating fruits, boiling, frying and using as substitutes of pulses, cereals, potatoes to make local delicacy of "*githeri*" (mixture of beans and maize), or "*mukimo*" (mashed potatoes). Other recipes included mixing cooked pumpkin fruits with wheat flour and then cooking. These culinary traditions provide edible and culturally acceptable foods among the communities, and markedly influence knowledge, selection, use, and conservation of plant diversity (Howard, 2006). However during the survey, it was established that traditional foodstuff have declined in the communities due to changes in food habits and diets. Exotic foods have dominated and contributed to changes in food habits in rural areas. This could result in loss of crop genetic diversity and change of socio-cultural backgrounds among the communities in the surveyed areas (Oniang'o *et al*., 2003).

CONCLUSIONS AND RECOMMENDATIONS

Pumpkins have potential to be good food security crops. They are a rich source of vitamins, proteins, oils and minerals which are used in boosting body immunity and reversing symptoms of malnutrition. Germplasm collection and *in situ* conservation help to meet the challenge of loss of plant genetic diversity and extinction. The genetic diversity of local species can be used to develop improved pumpkin cultivars that can face evolving and limiting environmental challenges. Genetic diversity and conservation of local pumpkins is under serious threat due to introduction of exotic cultivars of narrow genetic base. Pumpkin cultivation is determined by short-term socio-economic factors such as financial gains. Cultural values that were used by ancestors to safeguard the diversity of pumpkins are no longer followed by many of the present farmers. There is increased isolation, inbreeding, and reduction of reproductive success, genetic diversity and persistence of local landraces. Farmers who are the custodians of genetic diversity should be encouraged and supported to preserve the local landraces. Collection and preservation of the local landraces should be prioritised and expedited to capture maximum genetic diversity useful for crop improvement before it is lost or rendered extinct. There is need to integrate efforts to support popularization of local landraces by: developing high quality seeds, disease-resistant, high yielding cultivars to improve commercial viability, and sponsoring cultural food festivals to promote indigenous foods. Analysis of nutrients and medicinal applications of naturalized pumpkins in Kenya needs to be done. Traditional food processing methods need to be explored to provide medicinal, nutritional and economic benefits to the local communities.

ACKNOWLEDGEMENT

This research was supported by funds from the KAPAP to whom we are most obliged. Authors are grateful to agriculture staff in Kakamega and Nyeri counties, and to Mr Manyengo, KAPAP representative in Kakamega for their collaboration, and to farmers who offered germplasm and participated in the surveys to give all important pumpkin information.

REFERENCES

Agbagwa, I.O., Ndukwu, B.C. and Mensah, S.I., 2007. Floral biology, breeding system, and pollination ecology of *Cucurbita moschata*, Duch. ex Lam Duch. ex Poir. varieties (Cucurbitaceae) from parts of the Niger Delta, Nigeria. Turk. J. Bot. 31: 451-458.

Ahamed, K.U., Akhter, B., Islam, M.R. Ara, N. and Humauan, M.R., 2011. An assessment of morphology and yield characteristics of pumpkin (*Cucurbita moschata*) genotypes in N. Bangladesh. Trop. Agric. Res and Ext., 14(1): 7-11.

Aubry, C., Shoal, R. and Erickson, V., 2005. Grass cultivars: Their origins, development and use on national forests and grasslands in the Pacific Northwest. Corvallis, Oregon: USDA Forest Service; Native Seed Network, Institute for Applied Ecology.

Awan, M. R., Jamal, Z. and Khan, A., 2013. Ethno-botanical studies of economically important plants from mountainous region of Gilgit-Baltistan, Pakistan. Sci., Tech. and Dev., 32(4): 308-318.

Balkaya, A., Cankaya, S. and Ozbakir, M., 2011. Use of canonical correlation analysis for determination of relationships between plant characters and yield components in winter squash (*Cucurbita maxima* Duch.) populations. Bulg. J. Agric. Sci., 17: 606-614.

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.

CIP-UPWARD., 2003. Conservation and sustainable use of biodiversity: A source book. International Potato Center-Users Perspectives with Research and Development, Los Banos, Laguna, Philippines. 3 Volumes.

Davari, A., Khoshbakht, K., Ghalegolab Behbahani, A. and Veisi, H., 2013. A qualitative assessment of diversity and factors leading to genetic erosion of vegetables: A case study of varamin, Iran. Internat. J. Agr. Sci., 3(3): 198-212.

David, L. F., David, J. A., Robert, J. W. and Andrew, G. Y., 2008. Relative frequency of sympatric species influences rates of interspecific hybridization, seed production and seedling performance in the uncommon *Eucalyptus aggregata*. Journal of Ecology, 96: 1198–1210.

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. pp. 31-63.

Friss-Hansen, E. and Bhuwon, S., 2000. Concepts and rationale of participatory approaches to conservation and use of plant genetic resources. *In*: Friss Hansen E, Bhuwon, S., Eds.. Participatory Approaches to the Conservation and Use of Plant Genetic Resources, pp 154-161. IPGRI, Rome.

Garmin., 2000. eTREK Summit: GPS. Available from http://www.garmin.com [Used 26th-30th March, and 16th - 20th April, 2012].

Holzman, J.P., Bohonak, A.J., Kirkendall, L.R., Gottlieb, D., Harari, A.R. and Kelley, S.T., 2009. Inbreeding variability and population structure in the invasive haplodiploid palm-seed borer (*Coccotrypes dactyliperda)*. J. Evol. Biol., 22: 1076–1087.

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.

Hoshino, A.A., Bravo, J.P., Nobile, P.M. and Morelli, K.A., 2012. Microsatellites as tools for genetic diversity analysis. *In*: Mahmut Caliskan, (Ed.). Genetic diversity in microorganisms. *In*: Tech, available from: http://www.intechopen.com/books/genetic-diversity-in-microorganisms/microsatellites-as-tools-for-genetic-diversity-analysis.

IBC., 2007. Country Report on the State of Plant Genetic Resources for Food and Agriculture. Ethiopia: Second Country Report on the State of PGRFA to FAO, August 2007, Institute of Biodiversity Conservation, IBC), Addis Ababa.

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

Kiriti, T. and Tisdell, C., 2003. Commercialization of Agriculture in Kenya: Case study of policy bias and food purchases by farm households. *In:* Working Paper No. 32 on Social Economics, Policy and Development. The University of Queensland, pp. 1-23.

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. Paper Presented at the 12th Biennial KARI, Scientific Conference on Transforming Agriculture for Improved Livelihoods through Agricultural Products Value Chains, 8-12 November 2010, KARI Headquarters, Nairobi, Kenya.

Masayi, N. and Netondo, G.W., 2014. Effects of sugarcane farming on diversity of vegetable crops in Mumias division, western Kenya. Int. J. Biodivers. Ecosyst., 2(1): 001-010.

Masterson, T., 2007. Female land rights, crop specialization, and productivity in Paraguayan agriculture. Working Paper No. 504. The Levy Economics Institute of Bard College, Pp. 1-28.

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 Breeding and Appl. Biotech., 12: 96-103.

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

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.

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.

Nakhauka, E.B., 2009. Agricultural biodiversity for food and nutrient security: The Kenyan perspective. Int. J. Biodivers. Conserv., 1(7): 208-214.

Naluwairo, R., 2011. Investing in orphan crops to improve food and livelihood security of Uganda's rural-poor: Policy gaps, opportunities and recommendations. ACODE Policy Research Series, No. 43, 2011. Kampala.

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.
Ngugi, I.K., Gitau, R. and Nyoro, J., 2007. Access to high value markets by smallholder farmers of African indigenous vegetables in Kenya, Regoverning Markets Innovative Practice series, IIED, London.
Nwofia , G.E., Nwogu, V.N. and Nwofia, B.K., 2012. Nutritional variation in fruits and seeds of pumpkins (*Cucurbita* spp.) accessions from Nigeria. Pakistan J. Nutr, 11, 10), 848-858.
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.
Oloyede, F.M., Agbaje, G.O., and Obisesan, I.O., 2013b. Effect of NPK Fertilizer on fruit development of pumpkin (*Cucurbita pepo* Linn.). American Journal of Experimental Agriculture, 3(2): 403-411.
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. East Africa. Afri. J. Env. Sci. and Tech., 2(9): 296-304.
Oniang'o, R.K., Mutuku, J.M. and Malaba, S.J., 2003. Contemporary African food habits and their nutritional and health implications. Asia Pacific J. Clin. Nutr., 12(3): 231-236.
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.
Onyishi, G.C., Ngwuta, A.A., Onwuteaka, C. and Okporie, E.O., 2013. Assessment of genetic variation in twelve accessions of tropical pumpkin (*Cucurbita maxima*) of South Eastern Nigeria. World Appli. Sci. Jour., 24(2): 252-255.
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.
Rhymer, J.M., and Simberloff, D., 1996. Extinction by hybridization and introgression. Annual Review of Ecology and Systematics, 27(1): 83–109.
Sun, J., Cheng, G.W. and Li, W.P., 2013. Meta-analysis of relationships between environmental factors and aboveground biomass in the alpine grassland on the Tibetan Plateau. BioGeosciences, 10: 1707-1715.
Weltzien, E. and Fischbeck, G., 1990. Performance and variability of local barley landraces in near-eastern environments. Plant Breed. 104: 58-67.
Zinash, A., Workneh, T.S. and Woldetsadik, K., 2013. Effect of accessions on the chemical quality of fresh pumpkin. Afr. J. Biotechnol., 12(51): 7092-7098.