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PRODUCTION, PROCESSING AND STORAGE TECHNIQUES OF AFRICAN NIGHTSHADE (*Solanum spp.*) SEEDS AND THEIR CORRELATIONS WITH FARMERS' CHARACTERISTICS IN WESTERN KENYA

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ABSTRACT

Nightshade (Solanum species) is a priority African indigenous vegetable of great importance that plays a significant role in nutrition, food security and income generation. Much research attention on nightshade has focused on leaf yields, nutritional value, agronomic practices and post-harvest handling. However, African nightshade production is mainly constrained by lack of quality seeds occasioned by methods of seed harvesting, processing and storage. This study sought to find out existing knowledge on methods of seed harvesting, processing and storage techniques and their associations with farmers' characteristics. A household survey was done in Siaya, Kakamega, Vihiga, Kisumu, Busia and Kisii counties in Kenya between June 2014 and June 2015. The survey targeted farmers who produced and processed nightshade seeds in a bid to document existing methods of nightshade seed harvesting, processing and storage techniques. Purposive sampling was conducted on the targeted counties so as to survey only households that grow and process nightshade seeds. Scheduled interviews together with structured questionnaires were used to collect data. A total of 60 farmers were interviewed. Data were collected on nightshade production, cultural practices, harvesting processing and storage techniques, seed accessibility and availability, seed quality, quantity, cost and the challenges facing the nightshade seed production. Data collected were subjected to descriptive statistics using Statistical Package for Social Sciences (SPSS) version 21. Significantly more women were involved in nightshade seed production than men ($X2= 4.81$, $P = 0.028$). While, the level of education of farmers significantly influenced seed sourcing ($X2 = 17.99$, $P = 0.021$), the age and sex of farmers did not affect seed sourcing. The choice of methods used for nightshade seed extraction was not significantly associated with age, sex and the level of education. Similarly, nightshade seed packaging and storage techniques are not influenced by age, sex and level of education. Nightshade seed processing techniques were predominantly traditional and the seed systems informal. Farmers produced their own seeds and stored them for periods of less than one year. Therefore, farmers should be trained on production, storage and use of quality African nightshade seeds and more studies that focus on improvement, standardising and formalizing nightshade seed systems should be done.

Key words: Indigenous vegetables, Nightshade seeds, Production, Harvesting, Processing, Storage techniques, Seed systems

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INTRODUCTION

African nightshade (Solanum spp.) is a group of African Indigenous Vegetable (AIV) species that are cultivated and consumed in many parts of sub-Saharan Africa especially in Eastern, Western and Southern Africa. Nightshades have become commercially important crops in urban and peri-urban areas where they are traded for higher prices compared to exotic vegetables. They are considered among the priority AIV in production, consumption and trade [1], and plays a significant role in nutrition, food security and income generation [2]. Despite these benefits, supply of these vegetables lags behind the steadily rising demand due to challenges such as lack of quality seeds, lack of improved varieties that produce high yields among other constrains in production. For instance, nightshade leaves have a potential yield of 30-50 tonnes per hectare, yet farmers have been reported to obtain yields of between1.3-1.5 tonnes per hectare in Kenya [3].

Lack of quality seeds is a major challenge in the production of nightshade vegetable. The biggest constraint in African nightshade cultivation has been identified as lack of access to good seed stock [4, 5]. The poor seed quality is mainly occasioned by the methods farmers use in harvesting, processing and storage of seed. This has limited the access to quality seeds by farmers who entirely depend on seeds of poorly adopted traditional varieties, since seeds from adapted varieties are barely available, accessible or affordable leading to reduced and unsteady yields [6]. Most smallholder farmers prepare and preserve their own seed, which in most cases is of low quality due to the methods used in seed processing [7]. Proper seed handling during processing determines the seed quality, improve the mean germination time, seedling vigour and germination percentage of seeds [8]. Due to the growing demand for these vegetables, there is necessity to improve the quality of seeds so as to boost production and supply of the African nightshade vegetable [9]. The objective of this study therefore was to identify methods of seed harvesting, processing, packaging and storage of African nightshades and their associations with farmer characteristics in order to identify areas of improvement in the seed supply system of the African nightshade.

MATERIALS AND METHODS

Survey and seed collection

A survey was carried out in Siaya, Kakamega, Vihiga, Kisumu, Nakuru, Narok, Kericho, Busia and Kisii counties in Kenya between June 2014 and June 2015. The selected counties are known to have high activities in production, marketing and consumption of African nightshade. The survey targeted farmers, local seed traders and agro vets that sell seeds from registered seed companies in a bid to collect and assess the quality of seeds that are available to farmers. Sample size of respondents per county was determined based on the proportion of farmers that grew nightshade in each county sampled. Scheduled interview guides together with structured questionnaires were used to collect data. A total of 60 farmers producing nightshade seeds were purposively selected for the interview. The study sought information on production characteristics, methods of seed harvesting, processing and storage, cultural practices, number of years

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in nightshade growing, varieties most preferred, seed accessibility, availability, quantity, cost and the challenges facing the nightshade seed industry.

Data analysis

Data collected were analysed using descriptive and inferential statistics such as frequencies, chi-square test using SPSS (Statistical Package for Social Sciences) version 21.

RESULTS AND DISCUSSION

Characteristics of nightshade seed producers from western Kenya

A total of 60 farmers, 21 (35%) males and 39 (65%) female, were sampled and interviewed from six counties. More women were involved in nightshade seed production than men (X2 = 4.81, df =1, P=0.028) (Figure 1). Of the farmers sampled, 8.3% were below the age of 30 years, 13.3% were in the age group 31 to 40, 68.3% were in the age group 41 to 50 while 10% were above 50 years of age (Table 1).

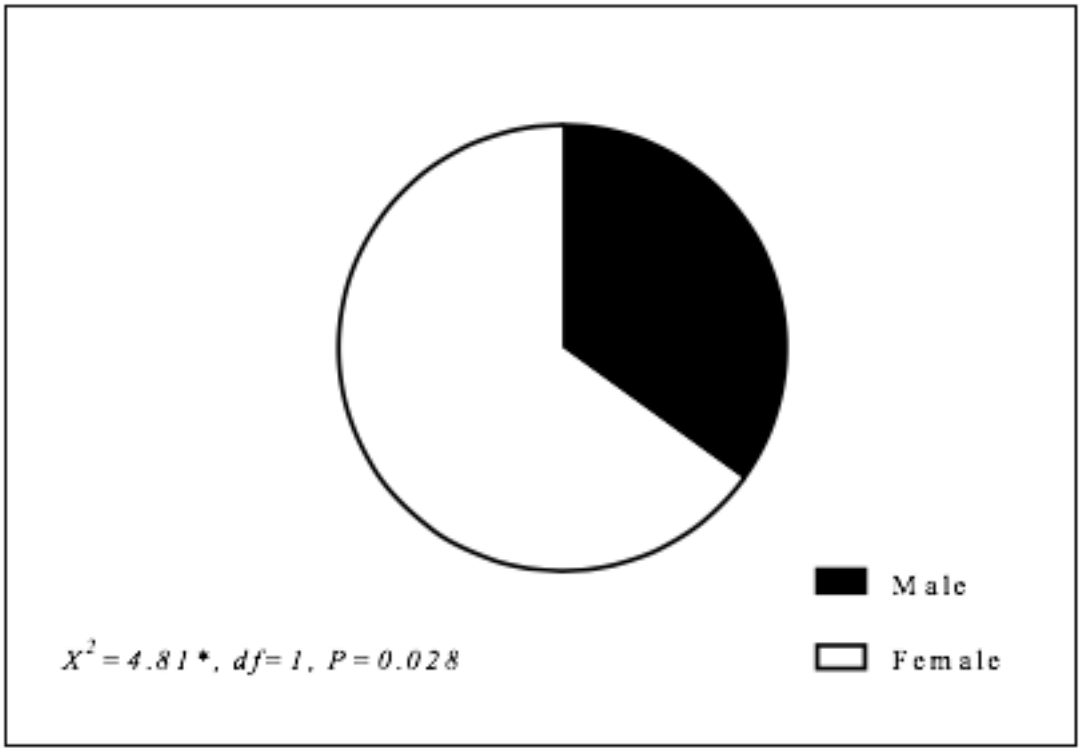

Figure 1: Distribution of nightshade seed producers in western Kenya by sex

Farming was the main source of income for most farmers (82%) with more than 76.6% of them earning more than $100 (10,000 Kenya shillings) per month from the farming enterprise (Table 1). Other sources of income included casual labour and local business. Most people (78%) involved in nightshade seed farming were over 40 years of age, with a few youths (8%) and young adults (13%) practicing farming. Among the farmers who were interviewed, majority (88%) had an experience of less than ten years in nightshade seed production (Table 1). Majority of the farmers were not employed and depended

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entirely on mixed farming and local business where they sell most of their farm produce. This is in agreement with a study that pointed out that subsistence farming and casual labour were the leading sources of income for households in Butere-Mumias District [10].

Nightshade seed availability and accessibility

The survey revealed that nightshade seed quality and availability was a problem, especially during the rainy seasons of planting with 76% of farmers citing nightshade seed availability as a major problem. Nightshade seed availability varied with the seasons. After the long rains, which occur between March and June, most farmers harvest berries when the nightshade plants are old and process the seeds. In most cases, the seed yields are very low (less than 1 kg per 0.10 ha of land) and barely enough for the next planting seasons. The scarcity of nightshade seeds is because the production is mainly left to small holder farmers who have limited channels in seed distribution [6]. The cost of nightshade seeds varied with the source and season. Most farmers (60%) indicated that there were higher costs during the planting season. The seeds that were available to farmers were of low quality with low germination and field emergence rates according to 80% of the farmers who obtained their seeds from alternative sources. During the rainy season, when majority of farmers prefer to plant nightshades, the demand for nightshade seeds is very high while the supply is low making the seeds very expensive and inaccessible for many farmers.

Nightshade seed production

Nightshade is predominantly drilled in rows by most farmers (87%) and thinned to leave the required plant population although some (13%) farmers prefer to plant in a nursery before transplanting the seedlings. The choice of planting method for nightshade seeds was not associated with the age of farmers ($X2=23.99$, $p=0.46$), sex ($X2=6.59$, $p=0.96$) and level of education ($X2=6.81$, $p=0.56$). The vegetable is grown using farm yard manure and hardly are inorganic fertilizers used. Nightshades are largely (96%) grown using any available farm yard manure that is a mixture of cow, goat, sheep, chicken and plant remains compost, which is applied during or before planting in no specific quantities but according to the amount available. Use of inorganic fertilizers for nightshade production is very limited (4%) since these fertilizers are expensive and farmers use the little quantities of the inorganic fertilizers they can afford for the production of the staple food crop (maize). The preference to use manure and fertilizer was not influenced by sex. There is also a general belief that traditional vegetables are adapted to low fertility soils and this has led to low or no application of fertilizers on this crop, thus the concurrent low leaf and seed yields [11].

Farmers characteristics and nightshade production management practices

Management practices such as weeding were carried out by all the sampled farmers to reduce competition with volunteer plants. Pest and disease control was practised by few (37%) farmers. Level of education significantly ($X2=19.85$, $p= 0.027$), influenced the use of pesticides for the control of pests and fungicides for the control of diseases. Most farmers who were educated up to the secondary and tertiary level of education practised pest and disease control compared to the less educated farmers. However, the use of pesticides for the control of pests was not dependent on age ($X2= 6.62$, $p=0.97$), and

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gender (X2=7.34, p=0.12). Vegetable plucking begins two to three weeks after planting depending on water and nutrient availability for the crop. The crop starts flowering 6-8 weeks after planting. When berries begin to form, the quantity of vegetables reduces and farmers allow the seeds to mature. Colour change from green to purple black for Solanum scabrum and green to orange yellow for Solanum villosum was the 100% index used by farmers to detect mature seeds. The mature berries are harvested by hand picking. The harvesting frequency for mature seeds varied across the farmers with majority (57%) of the farmers harvesting after every four days for a period of up to four weeks. In some cases, farmers leave the plants in the field and harvest only once.

Planting time for nightshade seeds varied among farmers. Although most farmers (77%) planted their nightshade during the long rains in March-July, the best season cited by 53% of the farmers for planting nightshade for maximum cost benefits was between November and February when the demand for vegetables is high and the supply is limited due to the dry spell experienced during this time of the year.

Nightshade seed sourcing

Most (71%) farmers produced and used their own saved seeds. Alternative sources of nightshade seeds for farmers who did not have their own seed included: borrowing from their neighbours or friends (75%), buying from local traders (17%) and buying certified seeds from agro vets, (Figure 2a). Nightshade seed sourcing was significantly influenced by the educational level of farmers, (X2=17.99, df =8, P=0.021), (Figure 2a). Farmers who were more educated had their alternative sources of their seeds from registered traders who sell certified seeds. This could be attributed to the fact that the farmers were well informed about the quality aspects of certified seeds hence they trusted seeds from registered traders than those from neighbours and local traders.

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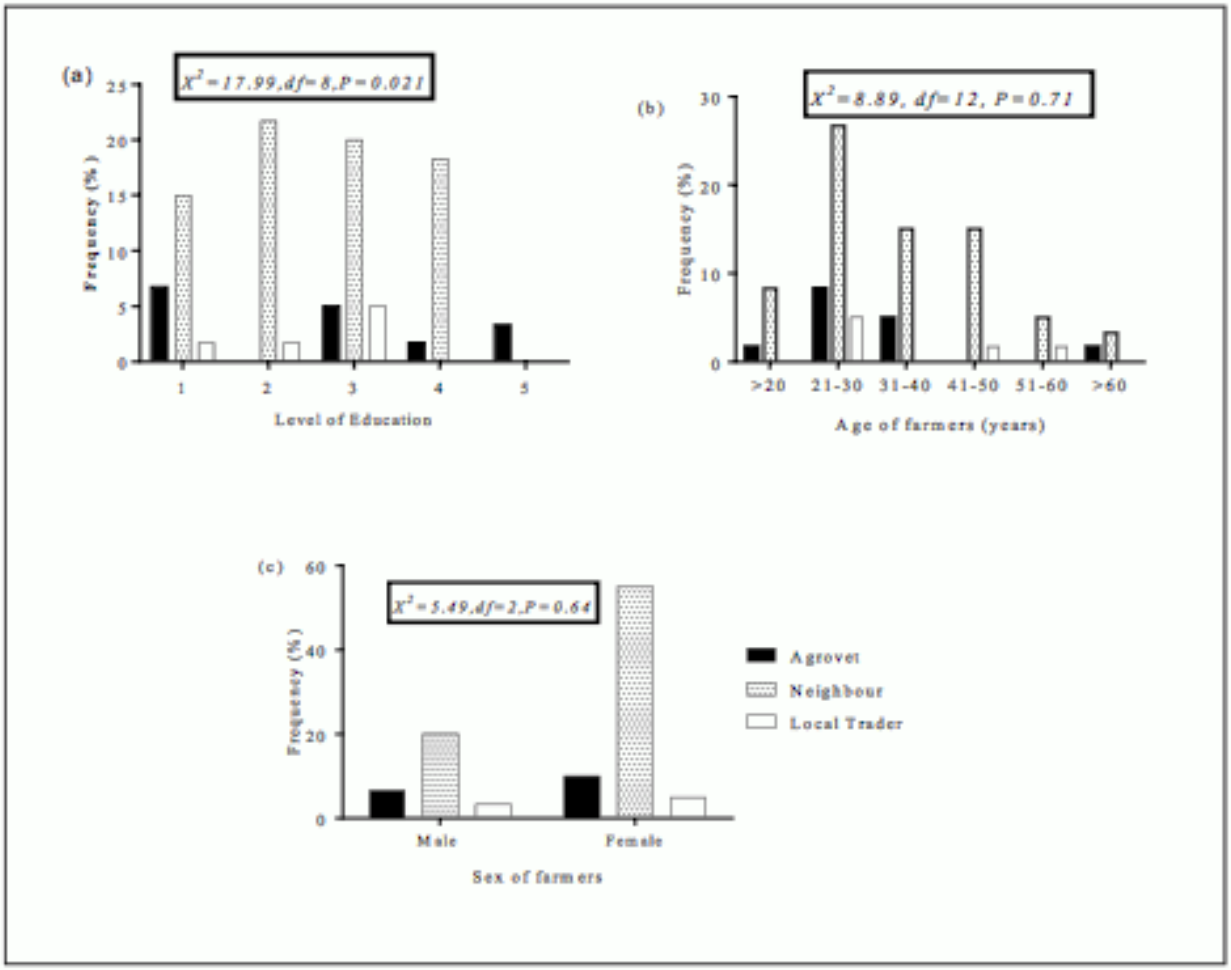

Education Level:
Level 0 – did not go to school
Level 1 – started but did not finish primary school
Level 2- only finished primary school
Level 3 – finished secondary school
Level 4- finished college

Figure 2: Relationship between alternative nightshade seeds source and (a) level of education, (b) age (c) sex of farmers in western Kenya

Although nightshade seed sourcing was independent of the age of farmers, (X2=8.89, df = 12, P=0.72) (Figure 2b) farmers between 21-30 years sourced their seeds from all the available sources (Figure 2c)., farmers aged between 40-60 years sourced their seeds from neighbours and registered traders only and did not buy seeds from local traders. Alternative nightshade seeds for farmers was not dependent on the sex of the farmers (X2 = 5.49, df = 2, P = 0.64). More women borrowed seeds from neighbours compared to men who preferred to buy seeds from local or registered traders in case they did not have their own seeds.

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Nightshade seed systems in Kenya are principally informal, with few companies producing advanced lines of the seeds. Although some companies and research institutions like Jomo Kenyatta University of Agriculture and Technology and World Vegetable Centre, Arusha produce and packaged some advanced lines, farmers from the target areas are yet to fully get involved in seed production due to lack of investment by seed companies in indigenous vegetables. These findings are in line with other studies [6] that reported that the rise in production of indigenous vegetables in East and Southern Africa is expected to result in an increase in seed demand. Nevertheless, there is little data on institutional, demographic and production characteristics of indigenous vegetable seed growers in East and Southern Africa. Also, there is inadequate documentation of services rendered by seed companies on indigenous vegetable seed growers [6]. As a result, most farmers entirely depend on their own produced seeds and largely borrow from neighbours and friends and/or buy from local traders in case they do not have their own seeds [12]. Previous estimates show that 66-85% of seeds used by resource-limited farmers in sub-Saharan Africa are sourced from informal markets and there are instances where the non-governmental organizations are involved in production and distribution of seeds [6]. Very few farmers buy seeds from registered companies, for they cited that the seeds are packaged in very small quantities yet cost thrice or four times as much as those sold by local traders.

Nightshade seed processing

Nightshade berries undergo a series of processing stages that include seed extraction, drying and cleaning. The methods used by farmers for seed extraction include fermentation (34%), with some farmers fermenting the seeds in a sack for periods ranging between 5 to 14 days and others fermenting the seeds in water for two to four days. Some farmers (66%) prefer to extract the seeds from the berries immediately the berries are harvested. Fresh seed extraction was the predominant seed extraction method used by farmers at all levels of education, age and gender (Figure 3). However, this was not significantly different ($X2=14.52$, $df= 16$, $p = 0.56$) from water and dry fermentation extraction methods. Farmers who were more educated only used fresh extraction method for seed processing (Figure 3a).

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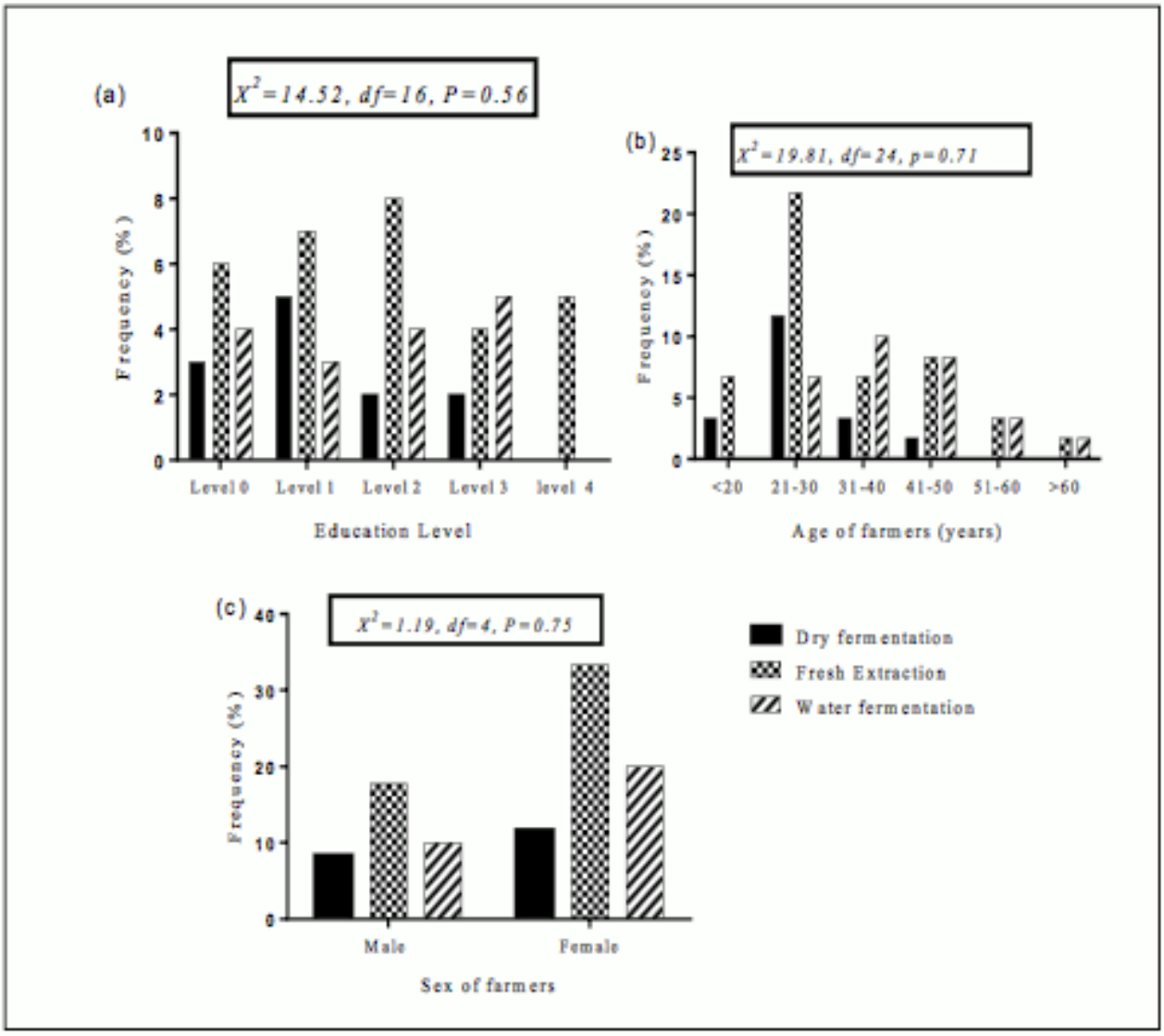

Figure 3: Relationship between nightshade seed extraction methods and (a) level of education, (b) age, (c) sex of farmers in western Kenya

The choice of nightshade seed extraction method(s) used by farmers was not dependent on the age of farmers (X2= 19.81, df = 24, P= 0.71). Farmers between 21-50 years were found to try out on most of the available methods of extraction compared to the young farmers below 20 years and the old farmers above 50 years of age (Figure 3b). The preference of seed extraction method used by farmers was independent of sex of farmers (X2= 1.90, df = 4, p = 0.7).

After seed extraction, 78% of the farmers washed the seeds severally to remove the berry debris while others dried the seeds together with the chaff. Farmers did not have any single standard method for processing nightshade seeds but used methods that they had learned from the older people and some tried to invent simpler methods that could take less time.

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Due to the laborious and time-consuming work involved in processing nightshade seeds, some farmers, (4%) did not harvest and process seeds. Instead they uprooted old plants with berries and placed them at a fertile place so that the berries could rot and some germinate during the next rainy seasons to be transplanted in the farm. Fermentation of berries was common among many farmers who claimed that fermentation made unripe berries to ripen thus making seed extraction easier. The process of fermentation was not standard; while some (54%) of the farmers immersed the berries in water and left them to ferment for some time; others (22%) wrapped the berries in woven sacks or polythene bags for some time to allow the berries to ferment. However, it was noted that fermentation of the berries may lead to seed rot thus loss of seed quality. It is recommended that to allow nightshade seed fermentation to take place and let the seeds be washed properly prior to drying so as to remove germination inhibitors that prevent the seeds from germinating [7]. This is because fermentation is a complicated process that needs to be done in a controlled environment for good results. Seed washing was then done by 67% of the farmers. This is a crucial step in the extraction process since it allows the washing off of sugars in the nightshade fruit pulp that may bring about dormancy in seeds. It was pointed out that many farmers experience problems with germination of African nightshade seeds caused by low vigour caused by inadequate removal of sugars and removal of germination inhibitors present in the fruit [7].

Drying of the seeds was predominantly under direct sun (80%) while some farmers prefer to dry the seeds under the shade. Seed drying was done on a range of materials: woven sacks (46.7%) polythene materials (20.6%), iron sheets (20%) and others like plywood and pieces of cloth. The seeds that were dried under direct sunlight take between 2 to 4 days depending on the intensity of the sun while the shade dried seeds take longer periods of up to ten days to dry. Farmers were able to tell that the seeds are adequately dry when they became friable and the chaff fell off. Nightshade seeds were dried in direct sunlight because seeds took shorter periods of time to adequately dry. Rapid seed drying of wet processed seeds may however affect the quality of seeds.

Nightshade seed packaging and storage

After the seeds are adequately dry, they are packaged in a variety of containers; before they are stored. The seeds were packed in plastic containers (50%), polythene bags (17%), khaki papers (26%) and traditional containers such as baskets and guards (7%). The plastic containers and polythene bags are widely used for packaging and storage of seeds because they are cheap and readily available to farmers. Some farmers pointed out that plastic containers and polythene bags were not suitable for storage of seeds because they made the seeds damp thus reducing their longevity and asserted that use of 'khaki' papers were an alternative better packaging material although it was a hypothesis that was not confirmed. The seeds were stored for a maximum of one year by majority (90%) of the farmers while only 10% stored the seeds for up to 36 months. Plastic containers were the most predominant packaging material used by farmers at all level of education, age and gender followed by polythene papers (Figure 4). The choice of packaging material farmers used to store their nightshade seeds was independent of the farmers' level of education ($X2 = 18.01$, $df = 20$, $P = 0.58$). Although farmers who were more educated used 'Khaki' papers and traditional baskets only for packaging their seeds before storage. Although plastic containers were majorly mainly used by farmers

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between 21-50 years, the choice of storage and packaging material was independent of age of farmers (X2 = 30.46, df = 30, P = 0.44).

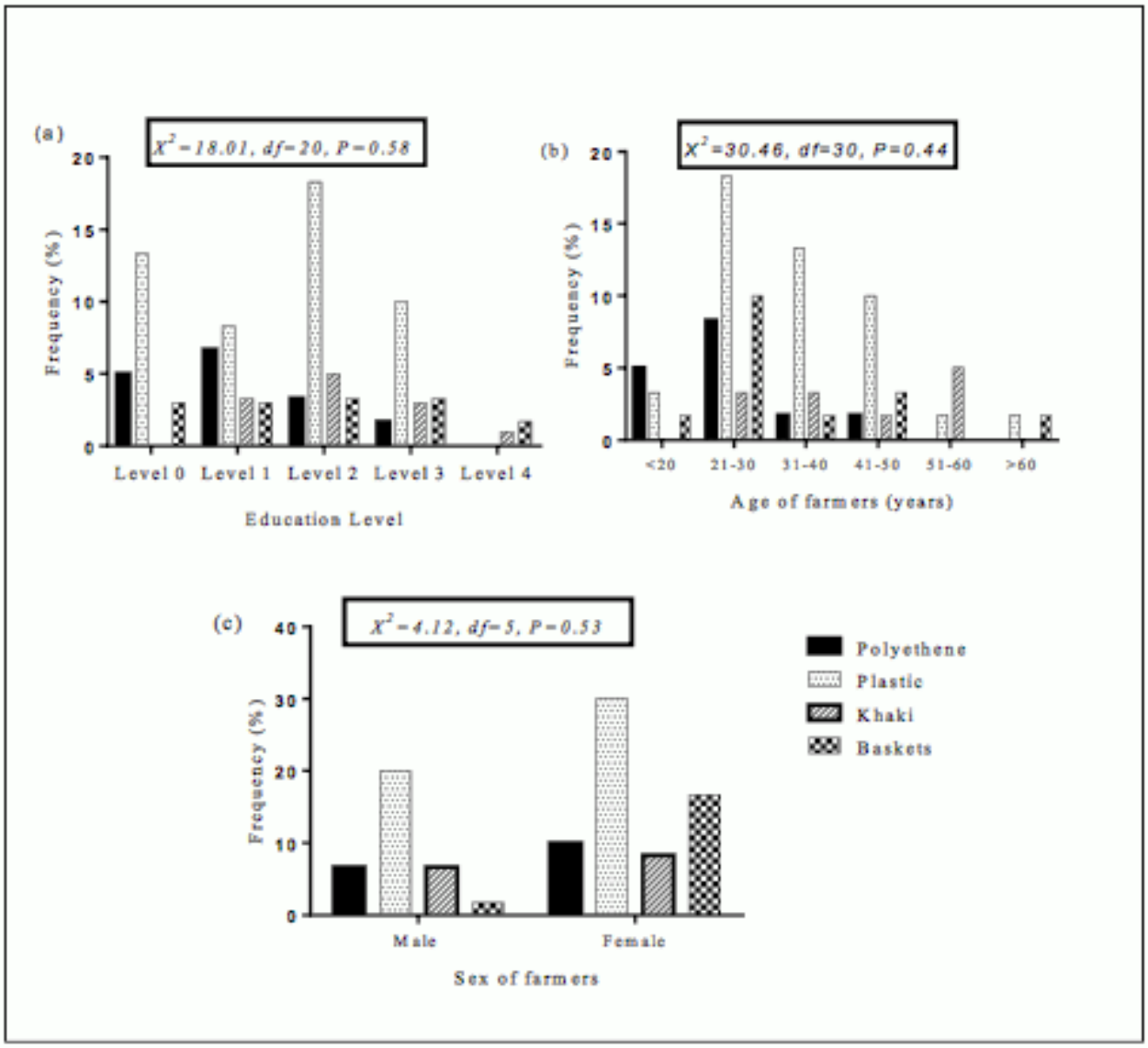

Figure 4: Relationship between nightshade seed packaging and storage methods and (a) level of education, (b)age (c) sex of farmers in western Kenya

Despite more women prefer plastic containers and traditional basket for storage of nightshade seeds, the farmers' choice for a particular packaging material was independent of sex, (X2 = 4.12, df = 5, P = 0.53), Figure 4(c).

It is recommended to package nightshade seeds in airtight container so that the seeds remain dry throughout the storage period [7]. However, this is not how the seeds are stored by majority (87%) of the farmers. Nightshade seeds can remain viable for several years when kept dry, but rapidly lose their germination capacity when stored in humid conditions [13]. Although the longevity of nightshade seeds is unknown, majority (93%) of farmers store the seeds for periods not exceeding two years. This could be attributed

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to the fact that limited quantities of seeds are produced and thus not much is left for storage after planting seasons.

Challenges of nightshade seed production, processing and marketing

Challenges faced by farmers during seed processing include: tedious seed processing techniques (77%), low seed yields (48%), loss of seeds during processing (40%), mixed varieties (31%), poor market channels (25%) and lack hybrid seeds at 17% (Figure 5). Other challenges were a lot of water needed for washing the seeds, seed rot during fermentation and foul smell together with sticky dye.

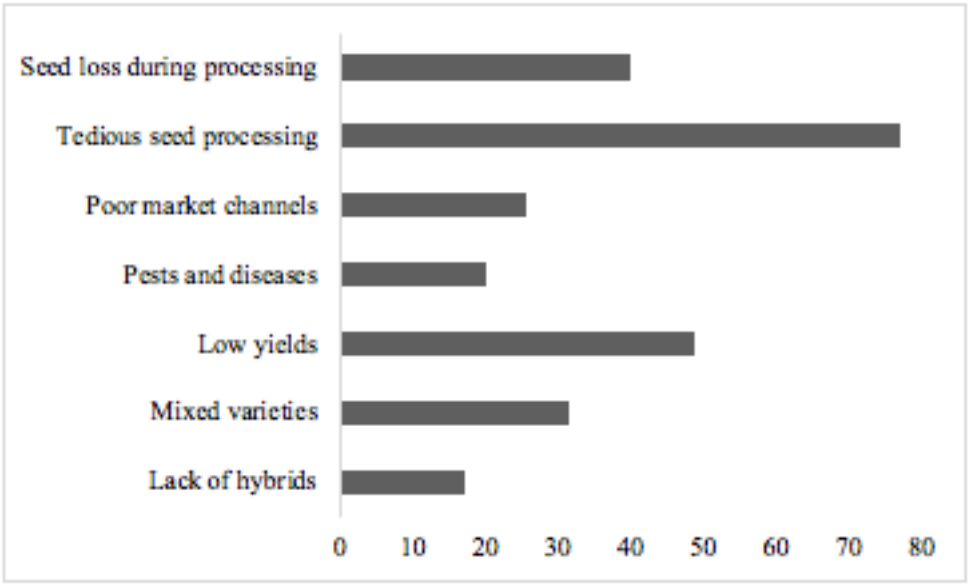

Figure 5: Challenges of processing nightshade seeds by farmers in Western Kenya

CONCLUSION

Although the production of nightshade vegetable has increased with the escalating demand, few farmers grow nightshade for the purpose of seed production. Women are more involved in nightshade seed production. More educated individuals source their seeds from certified seed dealers and from registered seed companies. Nightshade seed processing methods are predominantly based on indigenous knowledge with age, sex and education having no influence on the choice of methods used. Nightshade seed systems are informal; farmers produce, process and store their own seeds, which they share with their neighbours and friends and or sell the surplus to local traders.

Therefore, more studies that focus on the quality of seeds available to farmers and development of quality attributes for African nightshade seeds should be done in future in order to produce standard nightshade seeds that will lead to the formalization of the nightshade seed systems in Kenya.

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Table 1: Demographic information of nightshade seed farmers from western Kenya

	Frequency	Percentage (%)
Age distribution of nightshade vegetable seed farmers		
< 30 years	5	8.3
31 – 40	9	13.3
41- 50	41	68.3
51>	6	10.0
Sex distribution of nightshade farmers		
Men	21	35.0
Women	39	65.0
Nightshade seed production experience		
1 – 5	26	43.4
6 – 10	27	45.0
11 – 15	5	8.3
16>	2	3.3
Secondary Occupation		
Farming	49	81.6
Employed	3	5.0
Business within the community	6	10.0
Business out of the community	2	3.3

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