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Effect of washing, packaging material and storage period on the quality of sweet potato roots

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Abstract

Sweet potato storage hardly happens in Kenya since most farmers harvest the roots piecemeal on demand. Moreover, many traders have little knowledge on the appropriate conditions for storage. There exists very little information on stability of nutrients of these roots during storage. Kabode (orange fleshed) and Kenspot 2 (white fleshed) varieties of sweet potato were harvested and subjected to similar storage conditions for 21 days to monitor changes in moisture content, starch, reducing sugars, beta carotene and vitamin C. Half of the samples were washed while the similar half were unwashed before storage. Samples were stored both under room temperature 22-24oC, relative humidity 60-70% and at temperature of 12-13oC, relative humidity 80-90%. There was moisture loss of up to 82.9% (Kabode) and 53.2% (Kenspot-1); starch loss of up to 29.7% (Kabode) and 23.7% (Kenspot 2); reducing sugars increased up to 286% (Kenspot 2) and 148.4% (Kabode); beta carotene loss of up to 100% (Kenspot 2) and 79.6% (Kabode) as well as vitamin C loss of up to 56% (Kenspot 2) and 62% (Kabode) at the end of 21 days of storage. Significant ($p \leq 0.05$) higher losses were recorded in samples stored at room temperature (22-24oC) with relative humidity 60-70% compared to samples stored at 12-13oC with relative humidity ranging 80-90%. Sweet potato storage shelf life can therefore be enhanced by storing the roots in temperatures 12-13oC at 80-90% relative humidity conditions which slow down metabolic reactions responsible for nutrient degradation. Relevant stakeholders in the sweet potato value chain should work together towards designing and establishing sweet potato roots storage chambers to increase the commercial viability of the enterprise.

Keywords: *Sweet potato; storage; Kabode, Kenspot 2; relative humidity*

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Introduction

Postharvest loss reduction in food crops need to be considered as a critical measure in addressing current and future global food shortage (Maalekuu *et al.,* 2014). Root and tuber crops storage is a challenge that requires concerted efforts from all the value chain actors (Ezeocha and Ironkwe *et al.,* 2017). Sweet potato roots, after harvest and storage just like other several fresh vegetables, experience nutrient degradation as a result of cellular respiration and oxidation (Bouzari at al., 2015). Proper storage of sweet potato roots should therefore result in preserving the nutritional and physiological quality (Takayarasha and Rukovo, 1989) since the roots still remain active metabolically after being harvested (Vimala *et al.,* 2011). The high content of moisture in these roots especially the orange-fleshed cultivars, contributes to their high

perishability nature when they are stored in unfavourable conditions (Andrade *et al.*, 2009). To supply and maintain markets sustainably, up to a year storage of sweet potato roots is needed (Tomlins *et al.*, 2007). However, storage of the fresh roots is not a common practice in many parts of the world due to their high vulnerability to damage and high perishability as a result of their thin delicate skin besides the flesh moisture content that is high (Woolfe, 1987). In less developed countries, the challenge is compounded probably by the marginal value of the crop and inadequate resources. Sweet potato production and the value chain sustainability are thus hindered by lack of storage facilities (Tumuhimbise *et al.*, 2010). In some African countries, farmers in rural areas have traditional ways of storage like pit storage, in-ground storage and platform storage. Sweet potato storage in Kenya is generally insignificant since between 68% - 90% of farmers did not know how to store surplus sweet potato roots (Were *et al.*, 2013). The roots are mainly temporarily stored in gunny bags or spread on the ground at prevailing room temperature. Other researchers (Sugri *et al.*, 2017) indicate that up to one year shelf-life extension of sweet potato roots can be realized if proper pre-storage treatments are applied at temperatures between 12-15°C and relative humidity between 80-90%. This study aimed at finding out the effect of storage conditions on the moisture content, starch, reducing sugars, beta carotene and vitamin C in samples of two varieties of sweet potato roots grown in Kenya.

Materials and Methods

Materials acquisition

Fresh sweet potato roots of two varieties: Kenspot 2 (white fleshed) and Kabode (orange-fleshed) were obtained from the Kenya Agricultural and Livestock Research Organization (KALRO) farm in Kitale in March 2016 after 3-4 months growing. These were wrapped then transported within 24 hours to the University of Nairobi for analyses at the Food Science, Nutrition and Technology laboratories.

Experimental Design

Factorial experiment design of 2x2x3x2 yielding 24 treatment combinations was applied. The roots of each variety were divided into two batches; one batch washed while the other not washed. Each variety from each batch were packaged in three different packages: gunny bag, jute bag and plastic tray before being subjected to two storage regimes; at room temperature (22^{o}C-24^{o}C), Relative humidity 60-70% and in an enclosed chamber (fridge) at temperatures of 12^{o}C-13^{o}C, relative humidity 80-90%. Analyses of moisture, beta carotene, vitamin C, starch and reducing sugars contents were determined at day one, day seven, day fourteen and day twenty-one in the samples.

Reagents

All the reagents used were of analytical grade and were obtained from Sigma-Aldrich chemical company.

Proximate Analyses

Moisture Content

Moisture content in raw sweet potato was determined as per the AOAC (2005) method number 925.09B. About 2 grams composite sample of each variety were dried in air oven at 105^{o}C for 5hours, cooling in a desiccator and weighing again until a constant weight was reached. Moisture content was calculated as a result of weight loss due to evaporated water.

Starch contents

Starch from fresh roots was obtained as per the method of another study and involved washing, manual peeling of sweet potato roots, washing, grating, processing in the laboratory blender, sieving with muslin cloth, sedimentation, decantation and drying (Ikegwu *et al.*, 2009). Starch content was then calculated as a percentage of the sample weight.

Reducing sugars content

Reducing sugars were extracted from 10g of sample by procedure of Luff-schoorl method No. 4 of the IFFJP (1968).

β-carotene

Approximately 2g composite sample of roots of each sweet potato variety were used to estimate the β-carotene using the UV Spectrophotometric method based on the procedure as per IFFJP (1972).

Vitamin C content

Vitamin C was extracted from 2g sample using 25ml of 20% TCA solution, 5 ml of 4% KI solution and 3 drops of starch solution were added, the solution then titrated with N-bromosuccinamide solution. Vitamin C content was calculated and expressed as mg/100g.

Data Analysis

Data were analyzed using Genstat software 15th edition. Data on physicochemical properties of sweet potato roots and the effects of treatments on selected properties were subjected to ANOVA to establish variation in means of the variables at LSD p≤ 0.05.

Results

Moisture content %:

Table 1 shows the initial moisture content (MC) of Kenspot 2 (Ksp) variety 70±2.83, were significantly (p<0.001) lower than Kabode (Kb) variety 77±0.71. Samples that were washed and stored on trays at room temperature (WRTT) recorded lowest MC levels with storage time followed by samples that were unwashed and stored on trays at room temperature (URTT) for both varieties.

Table 1. Moisture content of sweet potato samples subjected to different packaging and temperature duration storage

SAMPLE	DAY 1	DAY7	DAY14	DAY21
Ksp- WFT	70±2.83a	65.50±0.71cdef	57.00±0.00c	44.50±2.12cd
Ksp- UFT	70±2.83a	66.00±2.53cdef	63.50±0.71defg	56.00±1.41efg
Ksp- WFGB	70±2.83a	68.00±0.00def	68.00±0.00ghjk	63.50±0.71ghijklm
Ksp- UFGB	70±2.83a	66.00±1.41cdef	66.00±0.00fghi	60.50±6.40efghijk
Ksp- WFJB	70±2.83a	65.00±1.41cde	59.00±0.00cde	58.00±0.00efghij
Ksp- UFJB	70±2.83a	64.50±0.71cd	61.00±0.00cdef	61.00±0.00efghijk
Ksp- WRTT	70±2.83a	54.00±1.41a	35.00±2.83a	12.00±1.41a
Ksp- URTT	70±2.83a	57.00±1.41ab	44.00±2.83b	21.50±0.71b
Ksp- WRTGB	70±2.83a	61.00±0.00bc	57.50±0.71cd	57.50±0.71efghi
Ksp- URTGB	70±2.83a	61.50±0.71bc	55.00±0.00c	57.00±0.00efgh
Ksp- WRTJB	70±2.83a	64.00±0.00cd	64.00±0.00efg	54.50±0.71ef
Ksp- URTJB	70±2.83a	61.50±0.71bc	59.50±0.71	52.50±3.54de
Kb- WFT	77±0.71b	74.00±1.41ghi	66.50±2.12fghi	65.50±2.12hijklmn
Kb- UFT	77±0.71b	73.50±0.71ghi	67.00±1.41fghij	66.50±0.71jklmn
Kb- WFGB	77±0.71b	76.50±0.71i	68.00±1.41ghijk	71.50±0.71mn
Kb- UFGB	77±0.71b	75.50±0.71hi	73.00±1.41jkl	70.00±1.41lmn
Kb- WFJB	77±0.71b	76.50±0.71i	75.00±1.41l	73.00±1.41n
Kb- UFJB	77±0.71b	74.50±0.71ghi	70.50±0.71hijkl	68.00±1.41klmn
Kb- WRTT	77±0.71b	61.50±2.12bc	43.00±2.83b	36.00±2.83c
Kb- URTT	77±0.71b	64.50±2.12cd	57.50±2.12cd	43.50±2.12c
Kb- WRTGB	77±0.71b	74.00±1.41fgh	71.50±0.71ijkl	67.00±1.41klmn
Kb- URTGB	77±0.71b	73.50±0.71ghi	70.50±0.71hijkl	67.50±0.71klmn
Kb- WRTJB	77±0.71b	70.50±0.71fgh	67.50±2.12ghij	66.00±1.41ijklmn
Kb- URTJB	77±0.71b	70.00±0.00efg	64.50±0.71efgh	62.00±1.41fghijkl
% CV		1.8	2.3	3.5
Grand mean		67.44	62.08	56.46
S.E		1.20	1.43	1.98
P value		<0.001	<0.001	<0.001

NB: means ±SD followed by same alphabetical letter in the same column aren't significantly different at p≤ 0.05.
Ksp- Kenspot 2 variety**, Kb-** Kabode variety**; U – U**nwashed**; W-** Washed**; FT –** Fridge Tray**; FGB –** Fridge Gunny Bag**; FJB –** Fridge Jute Bag**; RTT –** Room Temperature Tray**; RTGB –** Room Temperature Gunny Bag**; RTJB –** Room Temperature Jute Bag**.**

From the study, it is also evident that samples stored at room temperature experienced higher losses in moisture content compared to those under same packaging, stored at 12-13^{o}C in the fridge. Samples stored in gunny bags and jute bags exhibited lower losses in moisture content compared to those stored on trays when subjected to similar storage temperature conditions.

Moisture Content: Comparison of changes in individual samples as affected by length of storage

Moisture content losses after 7-day storage period significantly ($p<0.05$) varied, ranged from 2.9% (Ksp-WFGB) to 28.6% (Ksp-WRTT) in Kenspot 2 (Ksp) variety samples and in Kabode (Kb) variety samples ranged from 0.6% (Kb-WFGB and Kb-WFJB) to 20.1% (Kb-WRTT) as shown in Table 2. After fortnight storage, moisture losses significantly ($p<0.05$) reduced, ranging from 2.9% (Ksp-WFGB) to 50% (Ksp-WRTT) in KSP variety samples while in Kabode (Kb) variety, losses ranged from 2.6% (Kb-WFJB) to 44.2% 126(Kb-WRTT). At the end of 21-day storage, significant ($p<0.05$) moisture losses of between 9.3% (Ksp-WFGB) and 82.9% (Ksp-WRTT) were recorded in KSP variety samples while significant ($p<0.05$) losses of between 5.2% (Kb-WFSB) and as high as 129 53.2% (Kb-WRTT) were recorded in Kabode samples. Washed samples (-W) were more susceptible to higher moisture losses compared to the unwashed samples (-U) when subjected to similar storage conditions and time. Samples stored in the refrigerated condition (FT, FGB, FJB) from both varieties (Ksp and Kb) at 12-13^{o}C recorded significantly ($p<0.05$) lower losses in moisture compared to similar samples stored at room temperature 22^{o}C - 24^{o}C (RTT, RTGB, RTJB). In the current study there was significant gradual decrease in moisture content of the roots through the 21days of storage regardless of how they were stored.

Table 2: Moisture Content in individual samples as affected by length of storage

Sample	Day 1	Day 7	Day 14	Day 21	%CV	Mean	S.E	P-value
Ksp-UFGB	70±2.83^{b}	66.00±1.41^{ab}	66.00±0.00^{ab}	60.50±6.40^{a}	**5.0**	**65.6**	**3.26**	**0.168**
Ksp-UFJB	70±2.83^{c}	64.50±0.71^{b}	61.00±0.00^{a}	61.00±0.00^{a}	**0.6**	**64.12**	**0.354**	**<0.001**
Ksp-UFT	70±2.83^{c}	66.00±2.53^{bc}	63.50±0.71^{b}	56.00±1.41^{a}	**2.5**	**63.88**	**1.62**	**0.004**
Ksp-URTGB	70±2.83^{d}	61.50±0.71^{c}	55.00±0.00^{a}	57.00±0.00^{b}	**0.6**	**60.88**	**0.354**	**<0.001**
Ksp-URTJB	70±2.83^{c}	61.50±0.71^{b}	59.50±0.71^{b}	52.50±3.54^{a}	**3.0**	**60.88**	**1.837**	**0.003**
Ksp-**URTT**	70±2.83^{d}	57.00±1.41^{c}	44.00±2.83^{b}	21.50±0.71^{a}	**3.4**	**48.12**	**1.620**	**<0.001**
Ksp-WFGB	70±2.83^{c}	68.00±0.00^{b}	68.00±0.00^{b}	63.50±0.71^{a}	**0.5**	**67.38**	**0.354**	**<0.001**
Ksp-WFJB	70±2.83^{c}	65.00±1.41^{b}	59.00±0.00^{a}	58.00±0.00^{a}	**1.1**	**63.00**	**0.707**	**<0.001**
Ksp-WFT	70±2.83^{d}	65.50±0.71^{c}	57.00±0.00^{b}	44.50±2.12^{a}	**1.9**	**59.25**	**1.118**	**<0.001**
Ksp-WRTGB	70±2.83^{c}	61.00±0.00^{b}	57.50±0.71^{a}	57.50±0.71^{a}	**0.8**	**61.50**	**0.5**	**<0.001**
Ksp-WRTJB	70±2.83^{c}	64.00±0.00^{b}	64.00±0.00^{a}	54.50±0.71^{a}	**0.6**	**63.12**	**0.354**	**<0.001**
Ksp-WRTT	70±2.83^{d}	54.00±1.41^{c}	35.00±2.83^{b}	12.00±1.41^{a}	**4.1**	**42.75**	**1.732**	**<0.001**
Kb-UFGB	77±0.71^{c}	75.50±0.71^{bc}	73.00±1.41^{b}	70.00±1.41^{a}	**1.4**	**73.88**	**1.061**	**0.010**
Kb-UFJB	77±0.71^{d}	74.50±0.71^{c}	70.50±0.71^{b}	68.00±1.41^{a}	**1.2**	**72.50**	**0.866**	**0.002**
Kb-UFT	77±0.71^{c}	73.50±0.71^{b}	67.00±1.41^{a}	66.50±0.71^{a}	**1.2**	**71.00**	**0.866**	**<0.001**
Kb-URTGB	77±0.71^{d}	73.50±0.71^{c}	70.50±0.71^{b}	67.50±0.71^{a}	**0.8**	**72.12**	**0.612**	**<0.001**
Kb-URTJB	77±0.71^{d}	70.00±0.00^{c}	64.50±0.71^{b}	62.00±1.41^{a}	**1.2**	**68.38**	**0.791**	**<0.001**
Kb-**URTT**	77±0.71^{d}	64.50±2.12^{c}	57.50±2.12^{b}	43.50±2.12^{a}	**3.0**	**60.62**	**1.837**	**<0.001**
Kb-WFGB	77±0.71^{c}	76.50±0.71^{c}	68.00±1.41^{b}	71.50±0.71^{a}	**1.2**	**74.75**	**0.866**	**0.010**
Kb-WFJB	77±0.71^{c}	76.50±0.71^{b}	75.00±1.41^{ab}	73.00±1.41^{a}	**1.4**	**75.38**	**1.061**	**0.062**

Kb-WFT	77±0.71^{c}	74.00±1.41^{b}	66.50±2.12^{a}	65.50±2.12^{a}	**2.3**	**70.75**	**1.658**	**0.005**
Kb-WRTGB	77±0.71^{c}	74.00±1.41^{b}	71.50±0.71^{b}	67.00±1.41^{a}	**1.5**	**72.38**	**1.061**	**0.003**
Kb-WRTJB	77±0.71^{c}	70.50±0.71^{b}	67.50±2.12^{ab}	66.00±1.41^{a}	**1.9**	**70.25**	**1.323**	**0.004**
Kb-WRTT	77±0.71^{d}	61.50±2.12^{c}	43.00±2.83^{b}	36.00±2.83^{a}	**4.2**	**54.38**	**2.264**	**<0.001**

NB: means ±SD followed by same alphabetical letter in the same row aren't significantly different at p≤ 0.05.

Ksp- Kenspot 2 variety**, Kb-** Kabode variety**; U – U**nwashed**; W-** Washed**; FT –** Fridge Tray**; FGB –** Fridge Gunny Bag**; FJB –** Fridge Jute Bag**; RTT –** Room Temperature Tray**; RTGB –** Room Temperature Gunny Bag**; RTJB –** Room Temperature Jute Bag**.**

Starch content: Comparison of means of 24 samples as subjected to different packaging and temperature under same duration of storage

Table 3 shows the initial starch content of Kenspot 2 (Ksp) variety 13.8±0.12, were significantly (p<0.001) higher than Kabode (Kb) variety 12.6±0.04.

Table 3. Comparison of means of starch content in sweet potato samples subjected to different packaging and temperature under same duration of storage

SAMPLE	DAY 1	DAY7	DAY14	DAY21
Ksp- WFT	13.8±0.12b	13.39±0.17def	12.82±0.02fghi	12.53±0.04fghij
Ksp- UFT	13.8±0.12b	13.57±0.16f	13.45±0.16ghi	13.32±0.16hij
Ksp- WFGB	13.8±0.12b	13.55±0.08ef	13.40±0.18ghi	13.36±0.17ij
Ksp- UFGB	13.8±0.12b	13.77±0.12f	13.75±0.13i	13.71±0.13j
Ksp- WFJB	13.8±0.12b	13.71±0.19f	13.67±0.23hi	13.66±0.23j
Ksp- UFJB	13.8±0.12b	13.74±0.14f	13.7±0.08hi	13.71±0.11j
Ksp- WRTT	13.8±0.12b	13.12±0.63cdef	12.71±0.40fghi	10.50±0.09abcde
Ksp- URTT	13.8±0.12b	13.53±0.28ef	13.41±0.36ghi	11.21±0.18bcdef
Ksp- WRTGB	13.8±0.12b	13.25±0.35cdef	12.37±0.06efg	11.07±1.27bcdef
Ksp- URTGB	13.8±0.12b	13.53±0.28ef	12.63±0.16fgh	11.55±0.49bcdefgh
Ksp- WRTJB	13.8±0.12b	13.70±0.10f	13.44±0.40ghi	12.83±0.21fghij
Ksp- URTJB	13.8±0.12b	13.69±0.18f	13.65±0.19hi	13.10±0.18ghij
Kb- WFT	12.6 ±0.04a	11.67±0.20ab	11.44±0.30cde	11.32±0.16bcdef
Kb- UFT	12.6 ±0.04a	12.15±0.03bcd	12.14±0.02def	12.07±0.07defghij
Kb- WFGB	12.6 ±0.04a	12.41±0.06bcdef	12.28±0.06ef	11.88±0.02cdefghi
Kb- UFGB	12.6 ±0.04a	12.56±0.05bcdef	12.29±0.04ef	12.24±0.03efghij
Kb- WFJB	12.6 ±0.04a	12.54±0.03bcdef	12.46±0.02efg	11.46±0.16bcdefg
Kb- UFJB	12.6 ±0.04a	12.56±0.04bcdef	12.52±0.04efg	12.50±0.03fghij
Kb- WRTT	12.6 ±0.04a	10.36±0.33a	9.62±0.15a	8.86±1.04a
Kb- URTT	12.6 ±0.04a	12.10±0.28bcd	10.98±0.18bc	10.52±0.01abcde
Kb- WRTGB	12.6 ±0.04a	11.56±0.32ab	11.16±0.21bcd	10.59±0.40abcde
Kb- URTGB	12.6 ±0.04a	11.89±0.93bc	11.07±0.12bcd	10.45±0.40abcd
Kb- WRTJB	12.6 ±0.04a	11.38±0.38ab	10.33±0.76ab	9.95±0.30ab
Kb- URTJB	12.6 ±0.04a	12.19±0.35bcde	10.54±0.14abc	10.18±0.46abc
% CV	**0.7**	**2.4**	**2.0**	**3.4**
Grand mean	**13.19**	**12.75**	**12.33**	**11.77**
S.E	**0.09**	**0.31**	**0.25**	**0.40**
Fpr	**<0.001**	**<0.001**	**<0.001**	**<0.001**

NB: means ±SD followed by same alphabetical letter in the same column aren't significantly different at p≤ 0.05.

Ksp- Kenspot 2 variety, Kb- Kabode variety; U – Unwashed; W- Washed; FT – Fridge Tray; FGB – Fridge Gunny Bag; FJB – Fridge Jute Bag; RTT – Room Temperature Tray; RTGB – Room Temperature Gunny Bag; RTJB – Room Temperature Jute Bag.

Starch Content: Comparison of changes in individual samples as affected by length of storage

Losses in starch content after 7 days of storage ranged from 0% (Ksp-UFGB) to 4.7% (Ksp-WRTT) in Kenspot-1(Ksp) variety samples while in Kabode (K) variety samples losses ranged from 0.4% (K-UFGB) to 17.8% (K-WRTT) as shown in Table 4. After 14 days of storage, reported losses in starch content ranged from 0.2% (Ksp-UFGB) to 10.2% (Ksp-WRTGB) for Ksp variety and between 0.7% (K-UFJB) and 23.7%(K-WRTT) for Kabode (K) samples. Starch content losses of between 0.4% (Ksp-UFGB) to 23.7% (Ksp-WRTT) were reported in Ksp variety while between 0.9% (K-UFJB) and 29.7% (K-WRTT) were recorded in Kabode variety after 21days of storage. In both varieties, the roots showed a decreasing, though gradual trend in starch content through the 21days of storage. From the findings in the current study, it is evident that, unwashed roots, packaging in gunny or jute bags prior to storage and use of controlled temperatures of about 12-13^{o}C and relative humidity 80-90% slowed down the loss of starch during storage of roots and should therefore be encouraged.

Table 4: Comparison of changes in Starch Content in individual samples as affected by length of storage

Sample	Day 1	Day 7	Day 14	Day 21	%CV	Mean	S.E	Pvalue
Ksp-UFGB	13.77±0.12^{a}	13.77±0.12^{a}	13.75±0.12^{a}	13.71±0.12^{a}	**0.9**	**13.75**	**0.126**	**0.953**
Ksp-UFJB	13.77±0.12^{a}	13.74±0.12^{a}	13.71±0.12^{a}	13.70±0.12^{a}	**0.8**	**13.73**	**0.117**	**0.913**
Ksp-UFT	13.77±0.12^{b}	13.57±0.12^{ab}	13.45±0.12^{ab}	13.32±0.12^{a}	**1.1**	**13.53**	**0.149**	**0.135**
Ksp-URTGB	13.77±0.12^{c}	13.53±0.28^{c}	12.63±0.16^{b}	11.55±0.49^{a}	**2.3**	**12.87**	**0.302**	**0.006**
Ksp-URTJB	13.77±0.12^{b}	13.69±0.18^{b}	13.65±0.19^{b}	13.10±0.18^{a}	**1.3**	**13.55**	**0.170**	**0.050**
Ksp-**URTT**	13.77±0.12^{b}	13.53±0.28^{b}	13.41±0.36^{b}	11.21±0.18^{a}	**2.0**	**12.98**	**0.254**	**0.002**
Ksp-WFGB	13.77±0.12^{b}	13.55±0.08^{ab}	13.40±0.18^{ab}	13.36±0.17^{a}	**1.1**	**13.52**	**0.144**	**0.134**
Ksp-WFJB	13.77±0.12^{a}	13.71±0.19^{a}	13.67±0.23^{a}	13.66±0.23^{a}	**1.4**	**13.70**	**0.196**	**0.930**
Ksp-WFT	13.77±0.12^{c}	13.39±0.17^{b}	12.82±0.02^{a}	12.53±0.04^{a}	**0.8**	**13.13**	**0.107**	**0.001**
Ksp-WRTGB	13.77±0.12^{b}	13.25±0.35^{b}	12.37±0.06^{ab}	11.07±1.27^{a}	**5.2**	**12.62**	**0.660**	**0.052**
Ksp-WRTJB	13.77±0.12^{b}	13.70±0.10^{b}	13.44±0.40^{ab}	12.83±0.21^{a}	**1.8**	**13.44**	**0.241**	**0.053**
Ksp-WRTT	13.77±0.12^{b}	13.12±0.63^{b}	12.71±0.40^{b}	10.50±0.09^{a}	**3.0**	**12.53**	**0.381**	**0.004**
Kb-UFGB	12.61±0.04^{b}	12.56±0.05^{b}	12.29±0.04^{a}	12.24±0.03^{a}	**0.3**	**12.43**	**0.040**	**0.002**
Kb-UFJB	12.61±0.04^{a}	12.56±0.04^{a}	12.52±0.04^{a}	12.50±0.03^{a}	**0.3**	**12.55**	**0.038**	**0.155**
Kb-UFT	12.61±0.04^{b}	12.15±0.03^{a}	12.14±0.02^{a}	12.07±0.07^{a}	**0.4**	**12.24**	**0.043**	**0.002**
Kb-URTGB	12.61±0.04^{b}	11.89±0.93^{ab}	11.07±0.12^{a}	10.45±0.40^{a}	**4.5**	**11.50**	**0.512**	**0.048**
Kb-URTJB	12.61±0.04^{b}	12.19±0.35^{b}	10.54±0.14^{a}	10.18±0.46^{a}	**2.6**	**11.38**	**0.299**	**0.003**
Kb-**URTT**	12.61±0.04^{c}	12.10±0.28^{b}	10.98±0.18^{a}	10.52±0.01^{a}	**1.5**	**11.55**	**0.168**	**0.001**
Kb-WFGB	12.61±0.04^{d}	12.41±0.06^{c}	12.28±0.06^{b}	11.88±0.02^{a}	**0.4**	**12.29**	**0.047**	**0.001**
Kb-WFJB	12.61±0.04^{b}	12.54±0.03^{b}	12.46±0.02^{b}	11.46±0.16^{a}	**0.4**	**12.28**	**0.050**	**0.001**
Kb-WFT	12.61±0.04^{b}	11.67±0.20^{a}	11.44±0.30^{a}	11.32±0.16^{a}	**1.7**	**11.76**	**0.196**	**0.009**
Kb-WRTGB	12.61±0.04^{c}	11.56±0.32^{b}	11.16±0.21^{ab}	10.59±0.40^{a}	**2.4**	**11.48**	**0.277**	**0.008**
Kb-WRTJB	12.61±0.04^{c}	11.38±0.38^{bc}	10.33±0.76^{ab}	9.95±0.30^{a}	**4.1**	**11.06**	**0.454**	**0.014**
Kb-WRTT	12.61±0.04^{b}	10.36±0.33^{a}	9.62±0.15^{a}	8.86±1.04^{a}	**5.3**	**10.36**	**0.551**	**0.009**

NB: means ±SD followed by same alphabetical letter in the same row aren't significantly different at p≤ 0.05.
Ksp- Kenspot 2 variety, Kb- Kabode variety; U – Unwashed; W- Washed; FT – Fridge Tray; FGB – Fridge Gunny Bag; FJB – Fridge Jute Bag; RTT – Room Temperature Tray; RTGB – Room Temperature Gunny Bag; RTJB – Room Temperature Jute Bag.

REDUCING SUGARS: Comparison of means of 24 samples on a weekly basis as subjected to different packaging and temperature under same duration of storage

Table 5 shows the initial reducing sugars content of Kenspot 2 (Ksp) variety 2.50±0.14, were significantly (p<0.001) lower than Kabode (Kb) variety 2.57±0.08. Significant differences (p≤ 0.05) amongst the 24samples were noted after every

seven days of storage and the differences increased with length of storage. Reducing sugars content (%) in the samples were increased with storage period as shown in Table 6. Among Ksp variety samples, increases of between 4.2% (Ksp-UFGB) and 88% (Ksp-URTT), 6.6% (Ksp-WFJB) and 210% (Ksp-URTT) and between 7.8% (Ksp-UFT) and 286% (Ksp-WRTGB) after 7days, 14days and 21days storage respectively were recorded. In Kabode variety samples, reducing sugars increases ranging from 0.8% (K-URTT) to 49.8% (K-WRTGB) after 7days storage, increases ranging from 2.3% (K-UFT) to 113.2% (K-WRTT) after 14 days storage and the increases ranged from 3.1% (K-UFT) to 148.4% (K-URTJB) after 21 days storage.

Table 5: Comparison of means of Reducing sugars content for sweet potato samples subjected to different packaging and temperature under same duration of storage

	SAMPLE	DAY 1	DAY7	DAY14	DAY21
1.	Ksp- WFT	2.50±0.14a	2.73± 0.25a	2.78±0.21a	2.84±0.26a
2.	Ksp- UFT	2.50±0.14a	2.63±0.15a	2.67±0.13a	2.7±0.19a
3.	Ksp- WFGB	2.50±0.14a	2.75±0.18a	2.85±0.16ab	2.95±0.29ab
4.	Ksp- UFGB	2.50±0.14a	2.61±0.05a	2.93±0.05ab	3.01±0.08ab
5.	Ksp- WFJB	2.50±0.14a	2.67±0.08a	2.64±0.01a	2.73±0.02ab
6.	Ksp- UFJB	2.50±0.14a	2.71±0.06a	2.75±0.05a	2.96±0.01ab
7.	Ksp- WRTT	2.50±0.14a	3.63±0.16bcd	6.63±1.62de	7.26±0.74de
8.	Ksp- URTT	2.50±0.14a	4.7±0.08e	7.76±0.00e	7.835±0.01e
9.	Ksp- WRTGB	2.50±0.14a	3.65±0.01cd	7.44±0.01e	9.65±0.04f
10.	Ksp- URTGB	2.50±0.14a	3.2±0.02abcd	6.62±0.01de	7.34±0.06de
11.	Ksp- WRTJB	2.50±0.14a	3.04±0.03abc	6.02±0.26cde	8.19±0.35e
12.	Ksp- URTJB	2.50±0.14a	2.8±0.07a	5.32±0.5cd	5.77±0.76c
13.	Kb- WFT	2.57±0.08b	2.61±0.08a	2.68±0.14a	2.71±0.12ab
14.	Kb- UFT	2.57±0.08b	2.6±0.10a	2.63±0.1a	2.65±0.06a
15.	Kb- WFGB	2.57±0.08b	2.64±0.10a	2.68±0.07a	2.75±0.08ab
16.	Kb- UFGB	2.57±0.08b	2.64±0.06a	2.99±0.1ab	3.45±0.02ab
17.	Kb- WFJB	2.57±0.08b	2.84±0.17ab	3.08±0.05ab	3.2±0.01ab
18.	Kb- UFJB	2.57±0.08b	2.68±0.02a	2.94±0.16a	3.07±0.23ab
19.	Kb- WRTT	2.57±0.08b	3.68±0.33cd	4.41±0.48abc	5.48±0.59c
20.	Kb- URTT	2.57±0.08b	2.55±0.58a	3.02±0.91ab	3.95±0.41b
21.	Kb- WRTGB	2.57±0.08b	3.85±0.11d	4.94±0.01cd	5.89±0.16c
22.	Kb- URTGB	2.57±0.08b	3.77±0.22cd	5.07±0.00cd	6.32±0.01cd
23.	Kb- WRTJB	2.57±0.08b	3.24±0.13abcd	4.7±0.30bc	6.12±0.01cd
24.	Kb- URTJB	2.57±0.08b	3.06±0.10abc	4.44±0.00abc	6.39±0.01cd
	% CV	**4.6**	**5.8**	**10.1**	**6.1**
	Grand mean	**2.54**	**3.05**	**4.16**	**4.80**
	S.E	**0.12**	**0.18**	**0.42**	**0.29**
	P value	**1.00**	**<0.001**	**<0.001**	**<0.001**

NB: means ±SD followed by same alphabetical letter in the same row aren't significantly different at p≤ 0.05.
Ksp- Kenspot 2 variety, Kb- Kabode variety; U – Unwashed; W- Washed; FT – Fridge Tray; FGB – Fridge Gunny Bag; FJB – Fridge Jute Bag; RTT – Room Temperature Tray; RTGB – Room Temperature Gunny Bag; RTJB – Room Temperature Jute Bag.

Reducing Sugar Content: Comparison of changes in individual samples as affected by length of storage

Samples stored at room temperature 22-24^{o}C exhibited significantly (p≤0.05) higher increases in reducing sugars as storage time increased compared to those samples stored at temperatures 12-13^{o}C and relative humidity 80-90% for both varieties.

Table 6: Comparison of changes in Reducing sugar Content in individual samples as affected by length of storage

Sample	Day 1	Day 7	Day 14	Day 21	%CV	Mean	S.E	Pvalue
Ksp-UFGB	2.50±0.14^{a}	2.61±0.05^{a}	2.93±0.05^{b}	3.01±0.08^{b}	**3.2**	**2.76**	**0.090**	**0.012**
Ksp-UFJB	2.50±0.14^{a}	2.71±0.06^{ab}	2.75±0.05^{bc}	2.96±0.01^{c}	**2.9**	**2.72**	**0.080**	**0.022**
Ksp-UFT	2.50±0.14^{a}	2.63±0.15^{a}	2.67±0.13^{a}	2.7±0.19^{a}	**5.9**	**2.62**	**0.154**	**0.631**
Ksp-URTGB	2.50±0.14^{a}	3.2±0.02^{b}	6.62±0.01^{c}	7.34±0.06^{d}	**1.6**	**4.91**	**0.078**	**0.001**
Ksp-URTJB	2.50±0.14^{a}	2.8±0.07^{a}	5.32±0.5^{b}	5.77±0.76^{b}	**11.3**	**4.10**	**0.461**	**0.004**
Ksp-**URTT**	2.50±0.14^{a}	4.7±0.08^{b}	7.76±0.00^{c}	7.84±0.01^{c}	**1.4**	**5.70**	**0.083**	**0.001**
Ksp-WFGB	2.50±0.14^{a}	2.75±0.18^{a}	2.85±0.16^{a}	2.95±0.29^{a}	**7.3**	**2.76**	**0.201**	**0.286**
Ksp-WFJB	2.50±0.14^{a}	2.64±0.01^{a}	2.67±0.08^{a}	2.73±0.02^{a}	**3.1**	**2.63**	**0.082**	**0.179**
Ksp-WFT	2.50±0.14^{a}	2.73± 0.25^{a}	2.78±0.21^{a}	2.84±0.26^{a}	**8.1**	**2.71**	**0.221**	**0.520**
Ksp-WRTGB	2.50±0.14^{a}	3.65±0.01^{b}	7.44±0.01^{c}	9.65±0.04^{d}	**1.3**	**5.81**	**0.074**	**0.001**
Ksp-WRTJB	2.50±0.14^{a}	3.04±0.03^{a}	6.02±0.26^{b}	8.19±0.35^{c}	**4.6**	**4.94**	**0.229**	**0.001**
Ksp-WRTT	2.50±0.14^{a}	3.63±0.16^{a}	6.63±1.62^{b}	7.26±0.74^{b}	**17.9**	**5.00**	**0.890**	**0.015**
Kb-UFGB	2.57±0.08^{a}	2.64±0.06^{a}	2.99±0.1^{b}	3.45±0.02^{c}	**2.5**	**2.91**	**0.072**	**0.001**
Kb-UFJB	2.57±0.08^{a}	2.68±0.02^{ab}	2.94±0.16^{ab}	3.07±0.23^{b}	**5.2**	**2.81**	**0.146**	**0.078**
Kb-UFT	2.57±0.08^{a}	2.60±0.10^{a}	2.63±0.1^{a}	2.65±0.06^{a}	**3.0**	**2.61**	**0.080**	**0.768**
Kb-URTGB	2.57±0.08^{a}	3.77±0.22^{b}	5.07±0.00^{c}	6.32±0.01^{d}	**2.7**	**4.43**	**0.118**	**0.001**
Kb-URTJB	2.57±0.08^{a}	3.06±0.10^{b}	4.44±0.00^{c}	6.39±0.01^{d}	**1.6**	**4.11**	**0.065**	**0.001**
Kb-**URTT**	2.57±0.08^{a}	2.55±0.58^{a}	3.02±0.91^{a}	3.95±0.41^{a}	**19.1**	**3.02**	**0.577**	**0.191**
Kb-WFGB	2.57±0.08^{a}	2.64±0.10^{a}	2.68±0.07^{a}	2.75±0.08^{a}	**3.0**	**2.66**	**0.080**	**0.286**
Kb-WFJB	2.57±0.08^{a}	2.84±0.17^{ab}	3.08±0.05^{bc}	3.2±0.01^{c}	**3.4**	**2.92**	**0.098**	**0.011**
Kb-WFT	2.57±0.08^{a}	2.61±0.08^{a}	2.68±0.14^{a}	2.71±0.12^{a}	**4.2**	**2.64**	**0.111**	**0.631**
Kb-WRTGB	2.57±0.08^{a}	3.85±0.11^{d}	4.94±0.01^{cd}	5.89±0.16^{c}	**2.4**	**4.31**	**0.105**	**0.001**
Kb-WRTJB	2.57±0.08^{a}	3.24±0.13^{b}	4.7±0.30^{c}	6.12±0.01^{d}	**4.1**	**4.16**	**0.168**	**0.001**
Kb-WRTT	2.57±0.08^{a}	3.68±0.33^{ab}	4.41±0.48^{bc}	5.48±0.59^{c}	**10.4**	**4.03**	**0.419**	**0.010**

NB: means ±SD followed by same alphabetical letter in the same row aren't significantly different at p≤ 0.05.
Ksp- Kenspot 2 variety**, Kb-** Kabode variety**; U – U**nwashed**; W-** Washed**; FT –** Fridge Tray**; FGB –** Fridge Gunny Bag**; FJB –** Fridge Jute Bag**; RTT –** Room Temperature Tray**; RTGB –** Room Temperature Gunny Bag**; RTJB –** Room Temperature Jute Bag**.**

Beta carotene (mg/100g) (fwb): Comparison of means of 24samples on a weekly basis as subjected to different packaging and temperature under same duration of storage

Table 7 shows the initial beta carotene content of Kenspot 2 (Ksp) variety 0.06±0.02 mg/100g, were significantly ($p<0.001$) lower than Kabode (Kb) variety 4.33±0.16 mg/100g. Significant differences p≤ 0.05 especially amongst the Kabode (kb-) samples were noted after every seven days of storage and the differences increased with length of storage

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Table 7. Comparison of means of Beta carotene content for sweet potato samples subjected to different packaging and temperature under same duration of storage

SAMPLE	DAY 1	DAY7	DAY14	DAY21
Ksp- WFT	0.06±0.02a	0.05±0.02a	0.02±0.00a	0.02±0.01a
Ksp- UFT	0.06±0.02a	0.04±0.01a	0.01±0.00a	0.00±0.00a
Ksp- WFGB	0.06±0.02a	0.04±0.01a	0.01±0.01a	0.01±0.01a
Ksp- UFGB	0.06±0.02a	0.03±0.01a	0.01±0.00a	0.01±0.01a
Ksp- WFJB	0.06±0.02a	0.04±0.01a	0.03±0.01a	0.01±0.00a
Ksp- UFJB	0.06±0.02a	0.01±0.00a	0.01±0.00a	0.03±0.01a
Ksp- WRTT	0.06±0.02a	0.01±0.00a	0.01±0.00a	0.01±0.00a
Ksp- URTT	0.06±0.02a	0.04±0.01a	0.02±0.01a	0.01±0.01a
Ksp- WRTGB	0.06±0.02a	0.05±0.01a	0.03±0.02a	0.01±0.01a
Ksp- URTGB	0.06±0.02a	0.01±0.01a	0.01±0.01a	0.00±0.00a
Ksp- WRTJB	0.06±0.02a	0.03±0.02a	0.03±0.02a	0.03±0.01a
Ksp- URTJB	0.06±0.02a	0.04±0.01a	0.04±0.01a	0.03±0.02a
Kb- WFT	4.33±0.16b	3.8±0.01j	3.02±0.04j	2.42±0.00i
Kb- UFT	4.33±0.16b	3.62±0.00h	2.59±0.01g	2.18±0.00h
Kb- WFGB	4.33±0.16b	2.31±0.01c	1.76±0.01d	1.52±0.01e
Kb- UFGB	4.33±0.16b	3.47±0.11g	2.61±0.01gh	1.10±0.01c
Kb- WFJB	4.33±0.16b	3.01±0.01e	2.89±0.12h	1.07±0.01c
Kb- UFJB	4.33±0.16b	2.05±.0.01b	1.05±0.00b	1.32±0.02d
Kb- WRTT	4.33±0.16b	3.91±0.01i	3.91±0.09i	2.29±0.03h
Kb- URTT	4.33±0.16b	3.84±0.04i	2.33±0.04f	0.88±0.01b
Kb- WRTGB	4.33±0.16b	3.24±0.03f	2.72±0.01g	2.52±0.10i
Kb- URTGB	4.33±0.16b	3.38±0.01g	1.96±0.00e	1.91±0.01g
Kb- WRTJB	4.33±0.16b	3.87±0.02j	1.85±0.00de	1.69±0.01f
Kb- URTJB	4.33±0.16b	2.60±0.00d	1.62±0.01c	1.00±0.02c
% CV	5.1	1.7	2.9	2.9
Grand mean	2.19	1.64	1.19	0.83
S.E	0.11	0.03	0.03	0.02
P value	<0.001	<0.001	<0.001	<0.001

NB: means ±SD followed by same alphabetical letter in the same column aren't significantly different at p≤ 0.05.
Ksp- Kenspot 2 variety, Kb- Kabode variety; U – Unwashed; W- Washed; FT – Fridge Tray; FGB – Fridge Gunny Bag; FJB – Fridge Jute Bag; RTT – Room Temperature Tray; RTGB – Room Temperature Gunny Bag; RTJB – Room Temperature Jute Bag.

Beta carotene Content: Comparison of changes in individual samples as affected by length of storage

Losses in beta carotene were reported with storage time as shown in Table 8. After seven days period, losses ranging from 9.1% (Ksp-WRTGB) to 90.9% (Ksp-URTGB) in Kenspot 2 (Ksp) variety samples and losses ranging from 9.6% (K-WRTT) to 52.7%(K-194 UFJB) in Kabode variety samples were reported. Losses ranging from 36.4% (Ksp-URTJB) to 90.9% (Ksp-WFGB) in Ksp variety and 9.6% (K-WRTT) to 75.7% (K-UFJB) in Kabode variety were recorded after 14days of storage. At the end of 21day storage, a range of between 54.6% (Ksp-URTJB) and 100% losses in Ksp variety samples and between 41.7% (K-WRTGB) and 79.6% (K-URTT) losses in Kabode samples were recorded depending on storage condition and packaging.

Table 8. Comparison of changes in Beta carotene Content in individual samples as affected by length of storage

Sample	Day 1	Day 7	Day 14	Day 21	%CV	Mean	S.E	P-value
Ksp-UFGB	0.06±0.02^{b}	0.03±0.01^{ab}	0.01±0.00^{a}	0.01±0.01^{b}	49.4	0.02	0.012	0.042
Ksp-UFJB	0.06±0.02^{b}	0.01±0.00^{a}	0.01±0.00^{a}	0.03±0.01^{ab}	44.7	0.03	0.011	0.043
Ksp-UFT	0.06±0.02^{c}	0.04±0.01^{bc}	0.01±0.00^{ab}	0.00±0.00^{a}	48.6	0.03	0.013	0.036
Ksp-URTGB	0.06±0.02^{b}	0.01±0.01^{a}	0.01±0.01^{a}	0.00±0.00^{a}	62.5	0.02	0.012	0.030
Ksp-URTJB	0.06±0.02^{a}	0.04±0.01^{a}	0.04±0.01^{a}	0.03±0.02^{a}	42.2	0.04	0.016	0.398
Ksp-URTT	0.06±0.02^{b}	0.06±0.02^{ab}	0.04±0.01^{ab}	0.02±0.01^{a}	47.6	0.03	0.014	0.080
Ksp-WFGB	0.06±0.02^{b}	0.04±0.01^{ab}	0.01±0.01^{a}	0.01±0.01^{a}	52.2	0.03	0.014	0.047
Ksp-WFJB	0.06±0.02^{a}	0.04±0.01^{a}	0.03±0.01^{a}	0.01±0.00^{a}	40.7	0.03	0.013	0.097
Ksp-WFT	0.06±0.02^{a}	0.05±0.02^{a}	0.02±0.00^{a}	0.02±0.01^{a}	45.7	0.03	0.015	0.149
Ksp-WRTGB	0.06±0.02^{b}	0.05±0.01^{ab}	0.03±0.02^{ab}	0.01±0.01^{a}	50.2	0.03	0.017	0.117
Ksp-WRTJB	0.06±0.02^{a}	0.03±0.02^{a}	0.03±0.02^{a}	0.03±0.01^{a}	58.3	0.03	0.020	0.046
Ksp-WRTT	0.06±0.02^{b}	0.01±0.00^{a}	0.01±0.00^{a}	0.01±0.00^{a}	49.9	0.02	0.011	0.030
Kb-UFGB	4.33±0.16^{b}	3.47±0.11^{g}	2.61±0.01^{gh}	1.10±0.01^{c}	3.4	2.87	0.097	0.001
Kb-UFJB	4.33±0.16^{d}	2.05±.0.01^{c}	1.05±0.00^{a}	1.32±0.02^{b}	3.6	2.18	0.079	0.001
Kb-UFT	4.33±0.16^{d}	3.62±0.00^{c}	2.59±0.01^{b}	2.18±0.00^{a}	2.5	3.18	0.078	0.001
Kb-URTGB	4.33±0.16^{c}	3.38±0.01^{b}	1.96±0.00^{a}	1.91±0.01^{a}	2.7	2.89	0.078	0.001
Kb-URTJB	4.33±0.16^{d}	2.60±0.00^{c}	1.62±0.01^{b}	1.00±0.02^{a}	3.3	2.38	0.079	0.001
Kb-URTT	4.33±0.16^{d}	3.84±0.04^{c}	2.33±0.04^{b}	0.88±0.01^{a}	2.9	2.84	0.083	0.001
Kb-WFGB	4.33±0.16^{d}	2.31±0.01^{c}	1.76±0.01^{b}	1.52±0.01^{a}	3.2	2.48	0.079	0.001
Kb-WFJB	4.33±0.16^{c}	3.01±0.01^{b}	2.89±0.12^{b}	1.07±0.01^{a}	3.6	2.82	0.101	0.001
Kb-WFT	4.33±0.16^{d}	3.8±0.01^{c}	3.02±0.04^{b}	2.42±0.00^{a}	2.4	3.39	0.080	0.001
Kb-WRTGB	4.33±0.16^{c}	3.24±0.03^{b}	2.72±0.01^{a}	2.52±0.10^{a}	2.9	3.20	0.093	0.001
Kb-WRTJB	4.33±0.16^{c}	3.87±0.02^{b}	1.85±0.00^{da}	1.69±0.01^{a}	2.7	2.93	0.079	0.001
Kb-WRTT	4.33±0.16^{c}	3.91±0.01^{b}	3.91±0.09^{b}	2.29±0.03^{a}	2.6	3.60	0.092	0.001

NB: means ±SD followed by same alphabetical letter in the same row aren't significantly different at p≤ 0.05.
Ksp- Kenspot 2 variety, Kb- Kabode variety; U – Unwashed; W- Washed; FT – Fridge Tray; FGB – Fridge Gunny Bag; FJB – Fridge Jute Bag; RTT – Room Temperature Tray; RTGB – Room Temperature Gunny Bag; RTJB – Room Temperature Jute Bag.

Vitamin c content (mg/100g) (fwb): Comparison of means of 24samples on a weekly basis as subjected to different packaging and temperature under same duration of storage

Initial vitamin C content in Kabode variety (23.48±1.73) was significantly ($p<0.05$) higher than in Kenspot 2 variety (17.12±1.28) as displayed in Table 9. Both varieties in the current study displayed considerable amounts of vitamin C. Significant changes were noticed in vitamin C content among the 24samples after every week of storage. Washed samples stored at room temperature on trays (WRTT) showed the highest loss in vitamin C among the 24samples while the unwashed samples stored in the refrigerated conditions in bags displayed least losses in Vitamin C.

Table 9. Comparison of means of Vitamin C content for sweet potato samples subjected to different packaging and temperature under same duration of storage

SAMPLE	DAY 1	DAY7	DAY14	DAY21
Ksp- WFT	17.12±1.28a	11.19±0.06ab	10.62±0.06b	10.46±0.16bc
Ksp- UFT	17.12±1.28a	13.84±1.12cde	12.50±0.04bcd	11.04±1.16bcd
Ksp- WFGB	17.12±1.28a	14.70±0.21def	13.75±0.25cdef	11.60±0.44cde
Ksp- UFGB	17.12±1.28a	16.39±0.74fg	14.39±0.52def	13.87±0.08fg
Ksp- WFJB	17.12±1.28a	15.74±0.21ef	15.09±0.09efg	13.80±0.76efg
Ksp- UFJB	17.12±1.28a	17.10±0.99fg	15.87±0.78efg	13.05±0.29defg
Ksp- WRTT	17.12±1.28a	10.69±0.04a	8.34±0.06a	7.51±0.45a
Ksp- URTT	17.12±1.28a	13.23±0.04bcd	10.63±0.41b	9.10±0.66ab
Ksp- WRTGB	17.12±1.28a	12.21±1.48abc	11.85±1.59bc	10.62±0.26bc
Ksp- URTGB	17.12±1.28a	15.39±0.07def	12.34±0.43bcd	11.56±0.01cd
Ksp- WRTJB	17.12±1.28a	14.82±0.59def	13.63±0.17cde	12.50±0.37cdef
Ksp- URTJB	17.12±1.28a	15.91±0.14efg	14.46±0.35def	12.40±0.53cdef
Kb- WFT	23.48±1.73b	19.53±0.08hi	17.18±0.38gh	16.84±0.39hi
Kb- UFT	23.48±1.73b	21.45±0.75ijk	19.38±0.08hi	18.38±0.01ij
Kb- WFGB	23.48±1.73b	21.99±0.08jk	21.02±0.06ij	20.55±0.25jk
Kb- UFGB	23.48±1.73b	22.43±0.23k	22.09±0.44j	22.19±0.37k
Kb- WFJB	23.48±1.73b	22.41±0.37k	22.21±0.26j	21.46±0.13k
Kb- UFJB	23.48±1.73b	22.42±0.54k	22.23±0.13j	22.14±0.13k
Kb- WRTT	23.48±1.73b	19.61±0.09hij	16.02±0.06fg	8.92±0.38ab
Kb- URTT	23.48±1.73b	18.27±0.51gh	16.88±0.82g	11.86±0.99cdef
Kb- WRTGB	23.48±1.73b	21.16±0.23ijk	19.37±0.35hi	14.98±0.50gh
Kb- URTGB	23.48±1.73b	22.34±0.42k	20.59±0.52ij	18.65±0.57ij
Kb- WRTJB	23.48±1.73b	22.12±0.06k	21.19±0.49ij	17.66±0.28i
Kb- URTJB	23.48±1.73b	22.30±0.49k	21.01±0.78ij	19.04±0.72ij
% CV	0.00	3.1	3.1	3.4
Grand mean	20.30	17.80	16.36	14.59
S.E	0.000	0.55	0.51	0.50
P value	0.000	<0.001	<0.001	<0.001

NB: means ±SD followed by same alphabetical letter in the same column aren't significantly different at p≤ 0.05.
Ksp- Kenspot 2 variety, Kb- Kabode variety; U – Unwashed; W- Washed; FT – Fridge Tray; FGB – Fridge Gunny Bag; FJB – Fridge Jute Bag; RTT – Room Temperature Tray; RTGB – Room Temperature Gunny Bag; RTJB – Room Temperature Jute Bag.

VITAMIN C: Comparison of changes in individual samples as affected by length of storage

Losses in vitamin C content after 7-day storage period significantly ($p<0.05$) ranged from 0.01% (Ksp-UFJB) to 38% (Ksp-WRTT) in KSP variety samples and in Kabode (Kb) variety samples ranged from 4.5% (Kb-UFGB and Kb-UFJB) to 22% (Kb-URTT) as shown in Table 10. After fortnight storage, vitamin C losses significantly ($p<0.05$) ranged from 7.2% (Ksp-UFJB) to 51% (Ksp-WRTT) in KSP variety samples while in Kabode (Kb) variety samples, the losses ranged from 5% (Kb-WFJB) to 32% (Kb-WRTT). At the end of 21-day storage, significant ($p<0.05$) vitamin C losses of between 19% (Ksp-UFGB and Ksp-WFJB) and 56% (Ksp-WRTT) were recorded in KSP variety samples while significant ($p<0.05$) losses of between 5.5% (Kb-UFGB) and as high as 62% (Kb-WRTT) were recorded in Kabode samples. Washed samples (-W) were more susceptible to higher Vitamin C losses compared to the unwashed samples (-U) when subjected to similar storage conditions and time. Samples stored low temperature (-FT, -FGB, -FJB from both varieties of Ksp and Kb at 12-13^{o}C recorded significantly ($p<0.05$) lower losses in vitamin C compared to similar samples stored at room

temperature 22-24^{o}C (RTT, RTGB, RTJB). In each sample, there were significant (≤ 0.05) increases in vitamin C losses with increased storage time up to 21days.

Table 10. Comparison of changes in Vitamin C Content in individual samples as affected by length of storage

Sample	Day 1	Day 7	Day 14	Day 21	%CV	Mean	S.E	P-value
Ksp-UFGB	17.12±1.28^{b}	16.39±0.74^{b}	14.39±0.52^{a}	13.87±0.08^{a}	2.9	15.44	0.453	0.005
Ksp-UFJB	17.12±1.28^{b}	17.10±0.99^{b}	15.87±0.78^{b}	13.05±0.29a	4.1	15.79	0.646	0.009
Ksp-UFT	17.12±1.28^{c}	13.84±1.12^{b}	12.50±0.04^{ab}	11.04±1.16^{a}	5.9	13.62	0.805	0.007
Ksp-URTGB	17.12±1.28^{d}	15.39±0.07^{c}	12.34±0.43^{b}	11.56±0.01^{a}	1.6	14.10	0.219	<0.001
Ksp-URTJB	17.12±1.28^{d}	15.91±0.14^{c}	14.46±0.35^{b}	12.40±0.53^{a}	2.2	14.97	0.326	<0.001
Ksp-URTT	17.12±1.28^{d}	13.23±0.04^{c}	10.63±0.41^{b}	9.10±0.66^{a}	3.1	12.52	0.391	<0.001
Ksp-WFGB	17.12±1.28^{d}	14.70±0.21^{c}	13.75±0.25^{b}	11.60±0.44^{a}	1.9	14.29	0.275	<0.001
Ksp-WFJB	17.12±1.28^{c}	15.74±0.21^{b}	15.09±0.09^{b}	13.80±0.76^{a}	2.6	15.44	0.396	0.005
Ksp-WFT	17.12±1.28^{c}	11.19±0.06^{b}	10.62±0.06^{a}	10.46±0.16^{a}	0.7	12.35	0.092	<0.001
Ksp-WRTGB	17.12±1.28^{a}	12.21±1.48^{a}	11.85±1.59^{a}	10.62±0.26^{a}	8.4	12.95	1.094	0.014
Ksp-WRTJB	17.12±1.28^{d}	14.82±0.59^{c}	13.63±0.17^{b}	12.50±0.37^{a}	2.5	14.52	0.358	<0.001
Ksp-WRTT	17.12±1.28^{d}	10.69±0.04^{c}	8.34±0.06^{b}	7.51±0.45^{a}	2.1	10.91	0.229	<0.001
Kb-UFGB	23.48±1.73^{b}	22.43±0.23^{a}	22.09±0.44^{a}	22.19±0.37^{a}	1.4	22.55	0.309	0.033
Kb-UFJB	23.48±1.73^{b}	22.42±0.54^{a}	22.23±0.13^{a}	22.14±0.13^{a}	1.3	22.57	0.288	0.029
Kb-UFT	23.48±1.73^{c}	21.45±0.75^{b}	19.38±0.08^{a}	18.38±0.01^{a}	1.8	20.67	0.377	<0.001
Kb-URTGB	23.48±1.73^{c}	22.34±0.42^{c}	20.59±0.52^{b}	18.65±0.57^{a}	2.1	21.27	0.436	0.001
Kb-URTJB	23.48±1.73^{c}	22.30±0.49^{bc}	21.01±0.78^{b}	19.04±0.72^{a}	2.7	21.46	0.584	0.006
Kb-URTT	23.48±1.73^{c}	18.27±0.51^{b}	16.88±0.82^{b}	11.86±0.99^{a}	3.9	17.62	0.691	<0.001
Kb-WFGB	23.48±1.73^{d}	21.99±0.08^{c}	21.02±0.0^{b}	20.55±0.25^{a}	0.6	21.76	0.138	<0.001
Kb-WFJB	23.48±1.73^{c}	22.41±0.37^{b}	22.21±0.26^{b}	21.46±0.13^{a}	1.1	22.39	0.245	0.006
Kb-WFT	23.48±1.73^{c}	19.53±0.08^{b}	17.18±0.38^{a}	16.84±0.39^{a}	1.4	19.26	0.276	<0.001
Kb-WRTGB	23.48±1.73^{d}	21.16±0.23^{c}	19.37±0.35^{b}	14.98±0.50^{a}	1.7	19.75	0.328	<0.001
Kb-WRTJB	23.48±1.73^{d}	22.12±0.06^{c}	21.19±0.49^{b}	17.66±0.28^{a}	1.4	21.11	0.285	<0.001
Kb-WRTT	23.48±1.73^{d}	19.61±0.09^{c}	16.02±0.06^{b}	8.92±0.38^{a}	1.2	17.01	0.198	<0.001

NB: means ±SD followed by same alphabetical letter in the same row aren't significantly different at p≤ 0.05.
Ksp- Kenspot 2 variety**, Kb-** Kabode variety**; U – U**nwashed**; W-** Washed**; FT –** Fridge Tray**; FGB –** Fridge Gunny Bag**; FJB –** Fridge Jute Bag**; RTT –** Room Temperature Tray**; RTGB –** Room Temperature Gunny Bag**; RTJB –** Room Temperature Jute Bag**.**

Discussion

Moisture Content

The difference in the initial moisture content (MC) between the two varieties is likely due to genotypic difference between the two varieties. Orange-fleshed varieties are known to have higher moisture content than white and yellow fleshed varieties (Rukundo *et al.,* 2013). These values are within ranges (62.9% - 83.8%) reported in other studies (Aina *et al.,* 2009). Moisture content levels of sweet potato roots influence their acceptability by consumers and adoption by farmers (Rukundo *et al.,* 2013). Washing roots before storage especially for those stored on trays (without any packaging) should not be encouraged as it showed the highest and significant loss in moisture content. This could be probably because the relatively thin skin of the roots gets much exposure and vulnerable to moisture loss since manual washing is prone to bruising. From the study, it is also evident that samples stored at room temperature experienced higher losses in moisture content compared to those under same packaging, stored at 12-13^{o}C in the fridge. This could be attributed to the room's presumable higher temperature (22-24^{o}C) and lower relative humidity (60-70%) compared to the conditions in the fridge to support moisture loss into the environment. Samples stored in gunny bags and jute bags exhibited lower losses in moisture content compared to those stored on trays when subjected to similar storage temperature conditions. Storage of sweet potato roots at 12-13^{o}C, use of gunny bags and or jute bags should be encouraged to prolong the shelf life of the roots since they result in slower rates of moisture loss. The writer is not aware of any other published studies where roots were packaged in gunny bags and jute bags for comparison of results.

Washed samples (-W) were more susceptible to higher moisture losses compared to the unwashed samples (-U) when subjected to similar storage conditions and time. Samples stored in the fridge (FT, FGB, FJB) from both varieties (Ksp and Kb) at 12-13^{o}C recorded significantly ($p<0.05$) lower losses in moisture compared to similar samples stored at room temperature 22^{o}C - 24^{o}C (RTT, RTGB, RTJB). This can be attributed to the differences in relative humidity content between the fridge and the room. Lower relative humidity of the external environment facilitates quicker loss of moisture from the roots to the environment. In the current study there was significant gradual decrease in moisture content of the roots through the 21days of storage regardless of how they were stored. An experimental study elsewhere showed the moisture content in pit stored roots increased within the first 35days of storage then decreased but in one variety the moisture content decreased gradually (Namutebi *et al.,* 2004). High moisture content in sweet potato roots and thin skin makes them very perishable and challenging to store for long periods of time (Vimala *et al.,* 2011).

Starch content

These starch content values of these two varieties of sweet potato are within ranges (62.9% - 83.8%) reported in dry basis by other studies (Aina *et al.,* 2009). Orange-fleshed varieties are known to have higher moisture content than white and yellow fleshed varieties and the differences could be due to genotype (Rukundo *et al.,* 2013).

In both varieties, the roots showed a decreasing, though gradual trend in starch content through the 21days of storage. A decreasing trend of starch content was also noted in roots of six genotypes of sweet potato in another study as storage time increased up to 180 days (Dandago and Gungula, 2011). Losses of up to about 25.5% starch in non-cured roots stored in room conditions (23–26°C and relative humidity of 70–80%) for eight weeks, have been reported in other studies too (Nabubuya *et al.,* 2017). Decrease in starch content during storage of sweet potato roots has been linked to respiration in the roots where starch in the roots is the respiratory substrate (Ray and Ravi, 2005). From the findings in the current study it is evident that, unwashed roots, packaging in gunny or jute bags prior to storage and use of controlled temperatures of about 12-13^{o}C and relative humidity 80-90% slowed down the loss of starch during storage of roots and should therefore be encouraged. Starch is a very key ingredient for commercial use in both food and non-food applications. There is need to harness sweet potato starch so that it contributes immensely to the growing demand of starch for commercial use and subsequently

contribute to better incomes for sweet potato farmers.

Reducing sugars (mg/100g) (fwb):

These reducing sugars values in the current study are within ranges (1.74% - 2.5%) reported in other studies (Ingabire and Vasanthakaalam, 2011). Orange-fleshed varieties are known to have higher reducing sugars content than white and yellow fleshed varieties and this is largely due to genotype differences (Lymo *et al.,* 2010). The increase in significant differences p≤ 0.05 amongst the 24 samples after every seven days of storage can be attributed to the packaging and storage temperature.

In other studies, elsewhere sucrose and glucose concentration in stored sweet potato roots showed an increasing trend in early storage then remained at fairly constant levels. The increase in concentration of reducing sugars in stored sweet potato roots is found as a result of conversion of some starch in the roots to reducing sugars then to sucrose (Salunkhe and Kadam, 1998). Glucose and sucrose concentrations can increase by 1.35 % and 3.1% respectively during roots storage (Nabubuya *et al.,* 2017). The content of reducing sugars in sweet potato roots in most cases negatively correlates with starch content. Monitoring the changes in reducing sugars content in stored roots is very important since higher amounts are known to favour oxidation reactions which increase the cost of sweet potato processing (Mckibbin *et al.,* 2006). It is therefore necessary to store sweet potatoes in controlled temperatures less than 15^{o}C to slow down the rates at which starch can get converted into reducing sugars.

Beta carotene

These beta carotene values in the current study are within reported ranges (0.43 – 18.37mg/100g) by other studies (Niringiye *et al.,* 2014). Orange-fleshed varieties such as Kabode (Kb) are known to contain higher beta carotene content than yellow and white (such as Kenspot 2) fleshed varieties and the difference is largely attributed to genotype (Tumuhimbise *et al.,* 2013). The increase in significant differences (p≤ 0.05) especially among the Kabode variety samples after every seven days of storage can be associated with the packaging and storage temperature. Over 50% of provitamin A (beta carotene) were reported lost in studies elsewhere in six-week storage of sweet potato roots in jute sacks, basket and in ground trench (Wheatley and Loechl, 2013; Feruzi *et al.,* 2001)). Some earlier studies have however reported increase in beta carotene content during the storage of sweet potato roots. For instance, in an experimental study in Uganda, sweet potato roots stored in pits (17-21^{o}C, RH 90-100%) resulted in higher levels of beta carotene retention unlike roots that were stored in conditions that were ambient (24-27^{o}C, RH 68-100%) (Tumuhimbise *et al.,* 2010).

Curing and storage were found likely to increase beta carotene concentration of sweet potato roots (Okwuowulu, 2003). Carotene gain of up to 15% has also been reported in some varieties of sweet potatoes after storage. Beta carotene content variation in sweet potato cultivars may be a result of inherent differences in cultivars, maturity at harvest, storage time and storage conditions. It is of necessity that the stability of beta carotene in sweet potato roots during storage be established so that consumers get maximum nutritional benefit.

Vitamin c content

The difference in Vitamin C content between the two varieties can be attributed to variety since Kabode is orange fleshed while Kenspot 2 is white fleshed. The values are within values also reported in 21 Caribbean varieties varying from 5.2mg/100g to 31.2mg/100g (Aina *et al.,* 2009). Both varieties in the current study displayed considerable amounts of vitamin C. The recommended daily allowance of vitamin C for adults is 75mg/day (Bbalola *et al.,* 2010). Significant changes were noticed in vitamin C content among the 24samples after every week of storage. The changes are presumably due to the storage method and temperature. Sweet potato roots intended for storage should therefore not be washed then stored at cooler temperature below 15^{o}C for higher retention of Vitamin C. Washed samples (-W) were more susceptible to higher Vitamin C losses compared to the unwashed samples (-U) when subjected to similar storage conditions and time. Samples stored in the fridge (-FT, -FGB, -FJB from both varieties Ksp and Kb) at 12-13^{o}C recorded significantly ($p<0.05$) lower losses in vitamin C compared to similar samples

stored at room temperature 22-24^{o}C (RTT, RTGB, RTJB).

In each sample, there were significant (≤ 0.05) increases in vitamin C losses with increased storage time up to 21days. These losses can be possibly attributed to high solubility of vitamin C in water inform of moisture content, storage condition and package as well as the variety of sweet potato. Vitamin C loss in other studies has also been attributed to handling of the roots while at storage, method of extraction from samples and solvents used (Galani *et al.,* 2017).
Vitamin C easily oxidizes when exposed to adequate conditions during processing (Wilcox, 2006). Longer storage period and high temperatures during storage have been cited by some authors as facilitating factors in vitamin C loss among all vegetables (Lee and Kader, 2000). The losses of vitamin C usually begins immediately a crop is harvested and can be varied even among cultivars of the same commodity. In sweet potato roots, the loss can double per every 10^{o}C temperature rise. Storage of roots in atmosphere of less oxygen or with refrigeration[3] can however, slow down vitamin C loss.

Sweet potato stands out among other starchy staples in terms of ascorbic acid (vitamin C) content in amounts that are appreciable (Olatunde *et al.,* 2016). Vitamin C is well known for its antioxidant properties against free radicals in our bodies, anti-aging, lowering risks of certain cancers, improving iron absorption, rapid healing of wounds, improving the body's immune system and formation of a skin-making protein among other uses (Abdulla *et al.,* 2014; Babalola *et al.,* 2020; Everette and Islam, 2012). Vitamin C is among least stable nutrients and its stability after a given handling process can be used to also indicate stability of other nutrients[3].

Conclusion and recommendation

Both Kabode and Kenspot 2 varieties of sweet potato showed significant losses in moisture content, starch, reducing sugars, beta carotene and vitamin C during the 21days of storage. Losses were significantly ($p \leq 0.05$) higher in samples stored at room temperature 22-24^{o}C with relative humidity 50-60% compared to samples stored at 12-13^{o}C with relative humidity 80-90%. Packaging in jute and sisal bags ensured significant ($p \leq 0.05$) slower rates of nutrient losses compared to unpackaged samples. More research should be done to establish the effect of curing on stability of the nutrients in the samples under similar storage conditions as in this study.

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