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**EFFECTIVENESS OF WASHING AND PACKAGING ON SHELF LIFE EXTENSION OF
FRESH WHOLE KALES**

By

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DECLARATION

This is my original work and has not been presented for a degree in any other university

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ACKOWLEGDEMENT

I thank God for His great favor and provision for enabling me to come this far. I am especially grateful to Mr. Mbogo for his individual assistance, guidance and patience to my questions; I feel a deep sense of gratitude. I also thank the lab technicians; Rosemary and Muthika for being very supportive all through.

Many thanks go to Prof. J K Imungi for constant correction and his commitment to see this work a success, God bless you mightily.

DEDICATION

To my family,

I affectionately dedicate this work to you. Your support has been a never ending spring of hope,
your belief in me is a constant source of strength

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ABSTRACT

This study was carried out with the main objective of evaluating the effectiveness of washing and plastic bag packaging in shelf life extension of fresh whole kales. The specific objectives were to determine the effect of washing on water loss, loss of green color and ascorbic Acid content and to determine the effect of polythene bag packaging on water loss, loss of green color, beta carotene and Ascorbic acid content of stored kales.

One batch of fresh whole kales was washed with chlorinated (2ppm) water and a 2nd batch with non-chlorinated water. To determine effect of polythene bag packaging, samples from each batch were packaged in either perforated (4 holes each side) or non-perforated clear polythene bags (5×12 inches and 150 gauge). Storage was done at room and refrigerated temperature.

Percentage weight loss, retained Ascorbic acid, moisture content, and loss of green color of stored kales were determined at each sampling interval (after 2 days) during storage. Percentage weight loss was determined non-destructively (samples were returned to storage after weighing). Retained Beta carotene was analyzed on initial day and on the last day when kales quality was still acceptable. Ascorbic acid and beta carotene content values were adjusted from wwb to dwb.

Kales packed in non-perforated polythene bags and stored at room temperature for 6 days had 13% weight loss, 140.7mg/100g (dwb) (17.9%) reduced ascorbic acid, 2.9mg/100g (dwb) (12.3%) beta carotene and a color score of 2, while kales packed in non perforated polythene bags and stored in a refrigerator for 12 days had 7.5% weight loss, 640.5mg/100g (dwb) (81.34%) reduced ascorbic acid, 5.8mg/100g (dwb) (24.3%) beta carotene and a color score of 3.

From the analysis done it was concluded that washing with chlorinated water (2ppm) did not contribute to extension of shelf life of the fresh whole kales while packaging extended the shelf life of fresh whole kales. Kales that were not packed, packaged in non-perforated and perforated polythene bags and stored at room temperature had a shelf life of; 4, 6 and 4 days respectively while Kales which were not packaged, packaged in non-perforated and perforated polythene bags and stored in a refrigerator had a shelf life of 6, 12, 10 days respectively. These results show potential of polythene bag packaging in extending shelf life of fresh kale.

1.0 INTRODUCTION

Kale is a green leafy vegetable a form of cabbage, *Brassica oleracea* var. *acephala*, green or purple, in which the central leaves do not form a head. It is considered to be closer to wild cabbage than most domesticated forms. The species *Brassica oleracea* contains a wide array of vegetables including broccoli, cauliflower, collard greens, and brussels sprouts. The cultivar group *Acephala* also includes spring greens and collard greens, which are extremely similar genetically. Kale is considered to be a highly nutritious vegetable high in beta carotene, vitamin K, vitamin C, lutein, zeaxanthin, and reasonably rich in calcium. Kale, as with broccoli and other brassicas, contains sulforaphane (particularly when chopped or minced), a chemical believed to have potent anti-cancer properties. Along with other brassica vegetables, kale is also a source of indole-3-carbinol, a chemical which boosts DNA repair in cells and appears to block the growth of cancer cells.

Sabellian kale, are considered to be the ancestors of modern kales. Today one may differentiate between varieties according to the low, intermediate, or high length of the stem, with varying leaf types. The leaf colours range from light green through green, dark green and violet-green to violet-brown. Kales can be classified by leaf type as Curly leaved (Scots Kale), Plain leaved, Rape Kale, and Leaf and spear (a cross between curly leaved and plain leaved Kale).

Sukuma wiki (kale) and *ugali* (maize meal) provide a daily meal for many Kenyans. An inexpensive and healthy food *sukuma wiki*, together with cabbage and tomatoes, form the backbone of Kenya's domestic vegetable market. Kale is grown by 90 percent of smallholder farmers. But poor quality kale seed is often a problem for farmers, and local varieties tend to be poor yielding; flowering early and producing relatively small leaves. However, results from selection trials have yielded improved lines, which are proving extremely popular. The improved lines not only flower later, providing a longer period of production, but also produce a better quality leaf. Kale can be used as spinach substitute in a wide variety of dishes. Kale maintains body and crunch so can be used in dishes where spinach might not be suitable.

Kale requires fertile, well-drained loam soil, it is generally more disease and pest resistant than other brassicas, although it can experience similar problems. Kale are placed as the Most widely grown and sold vegetable in central and western highlands of Kenya. Marketing of kales presents challenges due to their perishable nature.

During harvesting one should choose leaves that are bright green and fresh, as opposed to yellowed leaves. The yellowish leaves can produce an undesirable taste, and their limp appearance may be unappetizing. When selecting kale, the leaves should be firm and deeply colored. It should have moist, hardy stems and no browning, yellowing or small holes on the leaves. Smaller leaves are chosen because they are more tender and mild in flavor. Washing before storing kale will help prevent spoilage and should be Stored in a cool environment. After harvesting, the organoleptic properties, nutritional value, safety and aesthetic appeal of kales deteriorates in varying degrees. Major causes of deteriorating include: growth and activity of micro-organism, insects and parasites, temperature both heat and cold, oxygen, moisture and dryness, light and time. Harvesting during coolest time of the day is desirable as the kales are not exposed to heat of the sun. If harvesting during hotter Part of the day cannot be avoided the produce should be kept shaded in the field to minimize product heat, weight loss and wilting. Pre-cooling also helps in product quality protection and thus extends shelf life by reducing rate of physiological change (rate of respiration and transpiration), retarding the growth of spoilage microorganism, reduce enzyme activity and reducing ethylene production. Care is needed to prevent mechanical damage of the product.

Kales, like other vegetables, are living, respiring and perishable products with active metabolism even after harvest from parent plant. Storage life and quality can be extended by modifying atmosphere surrounding product. A modified atmosphere can be defined as one that is created by altering the normal composition of air (21%oxygen and 0.03%carbon dioxide) to provide an optimum atmosphere for increasing the storage length and quality of kales. Modified atmosphere can be achieved by using controlled atmosphere (CA) storage or modified atmosphere packaging (map). Active modification occurs by the displacement of gases in the package, which are then replaced by a desired mixture of gases, while passive modification occurs when the product is packaged using a selected film type, and a desired atmosphere develops naturally as a

consequence of the products' respiration and the diffusion of gases through the film. MAP techniques involve either actively or passively controlling or modifying the atmosphere surrounding the product within a package made of various types of films. CA requires precise control of O₂ and CO₂ concentration around fresh product while MAP utilizes polymeric films with selective permeability for O₂, CO₂, and H₂O vapor to create an MA around the packaged product due to the respiration of the product and the selective permeability of the packaging material. MA reduces respiration rate, ethylene production, sensitivity, texture losses, improves chlorophyll and other pigment retention, delays senescence and reduces the rate of microbial growth and spoilage.

MAP relies on the interplay among natural respiration process of the product and the gas exchange through the package containing the product to generate and maintain the adequate atmosphere composition to product preservation. MAP is achieved by perforation to allow gas exchange in an otherwise gas-tight package. A single perforation or several perforations may act similarly to a polymeric film in the regulation of the gas exchange to provide the desired gas composition inside the package. Difference on relative humidity inside and outside the package is the driving force for water vapor movement and package is the physical barrier to this flow. In green vegetables, the senescence process usually leads to a yellow coloration of the tissue, because of the degradation of chlorophylls and the formation of pheophytins. The maintenance of refrigeration temperatures and a high relative humidity, combined with atmospheres lowered in O₂ and moderately enriched in CO₂, are shown to delay chlorophylls degradation

Kales quality is mainly based on appearance; fresh looking, well formed or well-shaped, right size, right maturity, right color, turgid or not wilted, free of defects such as rot, physical damage, yellowing or wilting and to some extent other attributes that cannot be seen but can be discerned by the other human senses such as firmness, tenderness and taste. Main causes of quality deterioration are wilting due to water loss, senescence-associated discoloration (yellowing or browning), mechanical injury, high respiration rate and decay or rotting. These causes of deterioration are physiological, pathological and mechanical in nature.

1.1 Problem Statement

- ❖ Kale is a very perishable product whose quality deteriorates after harvesting depending on handling conditions.
- ❖ Many farmers after harvesting bundle the kales and put them in sacks, these results to a lot of mechanical damage, high water loss and yellowing too soon during storage and transit to the market. Enormous post harvest losses occur during storage and transportation of kales from farm to market.
- ❖ In many homes, open markets and supermarkets, kales are stored in open atmosphere which result to a lot of moisture loss, wilting and finally yellowing.
- ❖ Studies on effectiveness of use of polythene films as a means of extending shelf life of kales has not been done and documented.
- ❖ If kales are harvested during heat of the day and not cooled immediately to remove field heat, they respire fast, loose water thus wilting, produce bad smell and eventually yellow faster.

1.2 Justification

- ❖ Kale is highly perishable and need to be preserved to extend their shelf life.
- ❖ Low density, plastic film is generally used for packing fresh vegetables and fruit owing to its high permeability and softness, can be sealed easily, has good O₂ and CO₂ permeability, low temperature durability, good tear resistance, and good appearance. It is therefore used for the production of MAP, which can be manipulated to match the characteristic respiration of produce by reducing O₂ levels to slow down the rates of respiration and senescence. Plastic film packaging produces MAP by passive modification of normal composition of air around the product through respiration and diffusion of gases through the film.
- ❖ MAP is very effective in retaining freshness and extending shelf life of fresh produce by maintaining the green color, inhibiting water loss, reducing loss due to product respiratory heat, and maintaining the natural fresh taste of produce. MAP is exemplified by the use of plastic film as packing material, which can be employed during transport

and storage. Plastic films can be used to pack specific volumes of produce, as individual wrapping, or as container liners. MAP is developed by use perforated plastic bags (4-8 holes at 5 mm diameter) or individual wrapping with the film.

- ❖ With the success of the study, consumers can purchase large volume because of possibility of preservation.

1.3 Main Objective

- ❖ To evaluate effectiveness of washing and plastic bags packaging in shelf life extension of fresh whole kales.

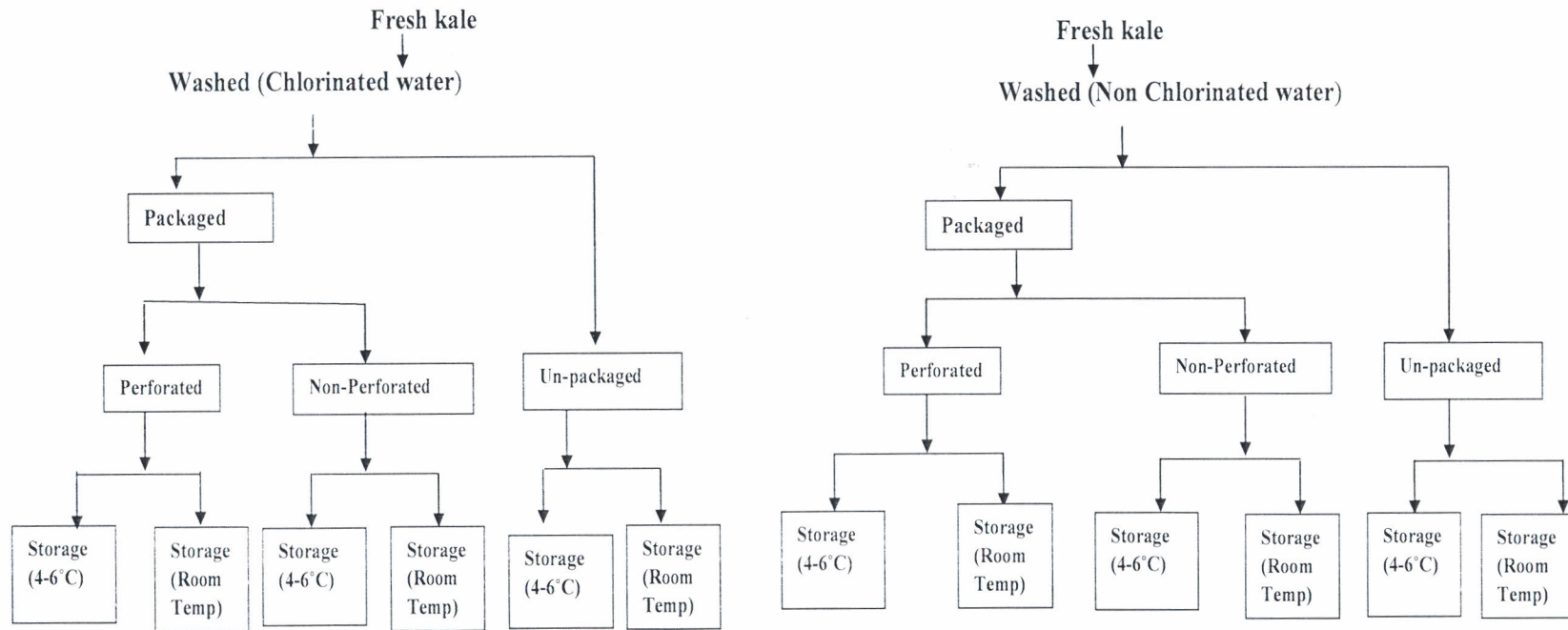
1.4 Sub-objective

- ❖ To determine effect of washing on water loss, loss of green color and ascorbic acid content of kales.
- ❖ To determine effect of polythene bag packaging on water loss, loss of green color, beta-carotene and ascorbic acid content of stored kales

1.5 Hypothesis

Plastic bag packaging and washing with chlorinated water of kales significantly extends their shelf life

2.0 RESEARCH DESIGN AND METHODOLOGY



2.1 Raw materials

Kales were obtained from UON field station. Kales were sorted to remain with kales of good quality which are free from: wilting, insect's bites and pest contaminants, yellowed leaves, not over-aged. Kales were then washed either in chlorinated or non-chlorinated water at room temperature to reduce microbial load and dirt. Some of the kales were packed and some were not packed. The kales were then stored in room temperature or refrigerated.

2.2 Polythene bags

Clear polythene bags 5*12 inches of 150 gauge were used. The polythene bags were either perforated or non-perforated. Perforation was done using a paper punch for uniformity. Four holes on each side were made totaling to 8 holes. After packaging the required samples, they were tightly tied by a rubber band to ensure modified atmosphere inside the package.

2.3 Determination of weight loss

Percentage average weight loss was determined by comparing average weight of three samples at each sampling date with original weight.

2.4 Determination of Reduced Ascorbic acid and Beta carotene

Ascorbic acid content and beta carotene was determined by methods of Association of Official Analytical Chemist. Reduced ascorbic Acid content was determined after every two days while beta carotene was determined at initial day and final day when quality of kale was good. Samples were done in double to minimize errors, and average was reported

2.5 Moisture content determination

To adjust ascorbic acid and beta carotene content values from wwb to dwb, Moisture content of each sample analyzed was determined by putting 2g sample in the oven overnight at 70°C. Percent moisture content was determined as a percent weight of dried sample to wet sample.

2.6 Determination of loss of green color

Loss of green color was evaluated subjectively. Color score of the kales leaves was awarded according to the scale; 5= Fresh green, as newly harvested; 4= fresh, light yellow on the top of some leaves; 3 = some parts of leaves de-greened, but still acceptable; 2= Approximate 30% of leaves de-greened and 1 = more than 50% of leaves de-greened.

3.0 RESULTS AND DISCUSSION

3.1 Effect of Washing on Shelf Life of Kales

KEY

- A- unpacked/non-chlorinated water/room temperature
- B- packed(non-perforated)/non-chlorinated water/room temperature
- C- packed(perforated)/non-chlorinated/room temperature
- D- unpacked/non-chlorinated water/refrigerated
- E- packed(non-perforated)/non-chlorinated water/refrigerated
- F- packed(perforated)/non-chlorinated water/refrigerated
- A'- unpacked/chlorinated water/room temperature
- B'- packed(non-perforated)/chlorinated water/room temperature
- C'- packed(perforated)/chlorinated/room temperature
- D'- unpacked/chlorinated water/refrigerated
- E'- packed(non-perforated)/chlorinated water/refrigerated
- F'- packed(perforated)/chlorinated water/refrigerated

3.1.1 Weight Loss

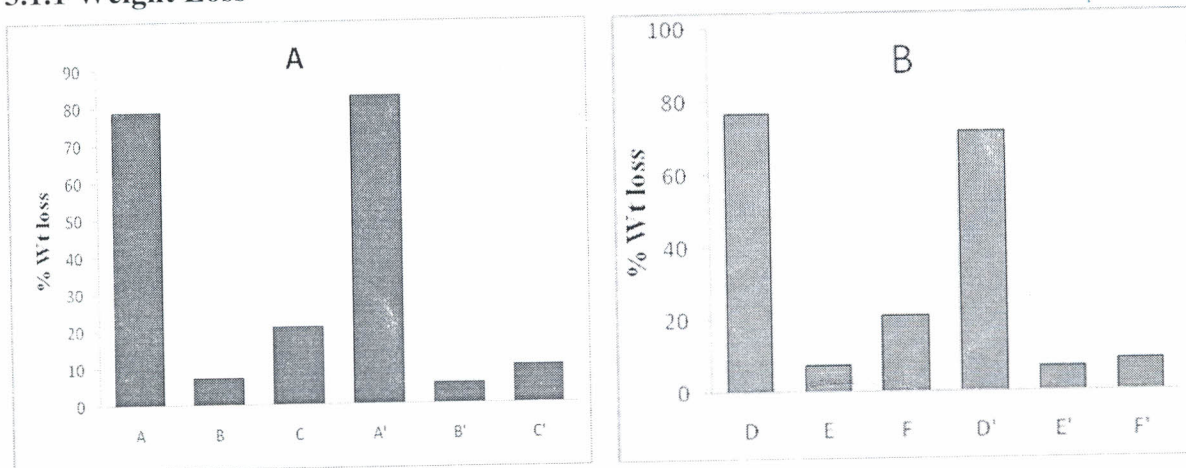


Fig 3.1 showing % wt loss of kales stored for 4 days at room (A) and 6 days at refrigeration (B) after washing with 2ppm Chlorinated water (A' B' C' D' E' F') and non chlorinated water (A B C D E F)

Weight loss occurred in all the samples washed with chlorinated water and non-chlorinated water, there was no significant difference on weight loss experienced in the two samples washed with different water.

3.1.2 Retained Ascorbic acid content

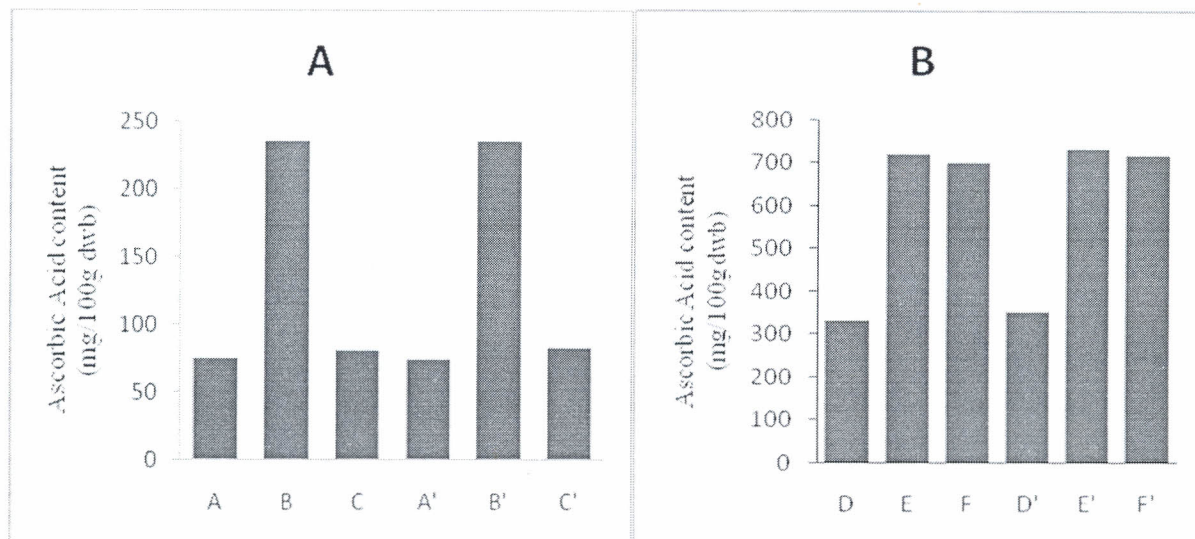


Fig 3.2 showing retained ascorbic acid content of kales stored for 4 days at room (A) and 6 days at refrigeration (B) after washing with 2ppm Chlorinated water (A' B' C' D' E' F') and non chlorinated water (A B C D E F)

Ascorbic Acid content in the collard green kales reduced during storage. There was no significant difference in rate of reduction of Ascorbic Acid content in the two differently washed samples with similar packaging and stored at same temperature.

3.1.3 Retained green Color

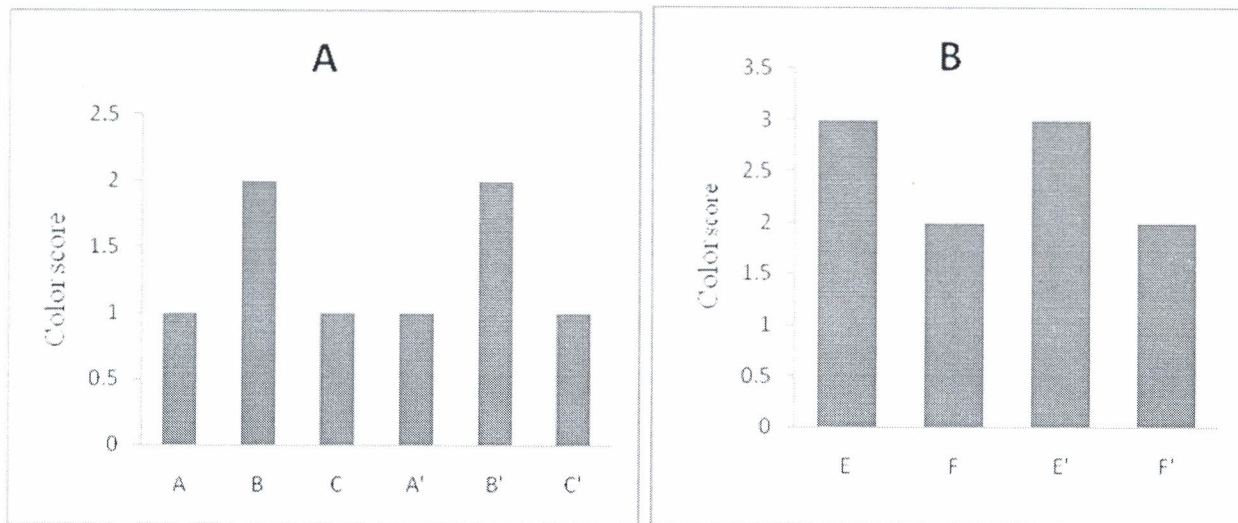


Fig 3.3 showing retained green color score of kales stored for 4 days at room (A) and 12 days at refrigeration (B) after washing with 2ppm Chlorinated water (A' B' C' D' E' F') and non chlorinated water (A B C D E F)

There was no significant effect on washing with chlorinated water on the loss of green color of the kales. The samples washed with non-chlorinated water and packed in non-perforated package and stored at room temperature had some rot spot on the sixth day, this was due to microbial contamination but in chlorinated water this was eliminated since chlorrine is bacterialcidal.

3.2 Effect of Polythene Bag Packaging on shelf life of kales

3.2.1 Weight loss

Percentage weight loss was least in samples packaged in non-perforated polythene bags, followed by those packaged in perforated polythene bags and highest weight loss was in the unpackaged samples. This trend was similar for samples stored at room or refrigerated temperature. This was because the polythene bag reduced the water vapor gradient between the sample and the outside air. Among the refrigerated samples, the unpacked samples, sample lost moisture at high rate due to low relative humidity in the fridge thus acting as the driving force for moisture loss.

Sample	Storage	% Weight Loss			
		Day 0	Day 2	Day 4	Day 6
Not packed	Room	0	37.28	78.66	-
Packed in Non perforated bag	Room	0	3.65	7.39	-
Packed in perforated bag	Room	0	4.29	20.89	-
Not packed	Refrigerator	0	42.12	64.81	76.78
Packed in Non perforated bag	Refrigerator	0	4.39	5.46	7.50
Packed in Perforated bag	Refrigerator	0	17.55	19.17	20.83

Table 3.1 shows % wt loss of kales.

3.2.2 Retained green color

Sample	Storage	Retained Green color score			
		Day 0	Day 2	Day 4	Day 12
Not packed	Room	5	3	1	-
Packed in Non Perforated	Room	5	4	3	-
Packed in Perforated	Room	5	4	1	-
Not packed	Refrigerator	5	5	5	-
Packed in Non Perforated	Refrigerator	5	5	5	3
Packed in Perforated	Refrigerator	5	5	5	2

Table 3.2 showing retained green color score of kales stored up to 4 days at room and 12 days at refrigeration.

The packed kales samples packaged retained their green color more than the control samples. Among the packaged samples the non-perforated samples retained their green color more than the perforated packaged kales. This was due to concentration of carbon dioxide in the package reducing degradation of chlorophyll.

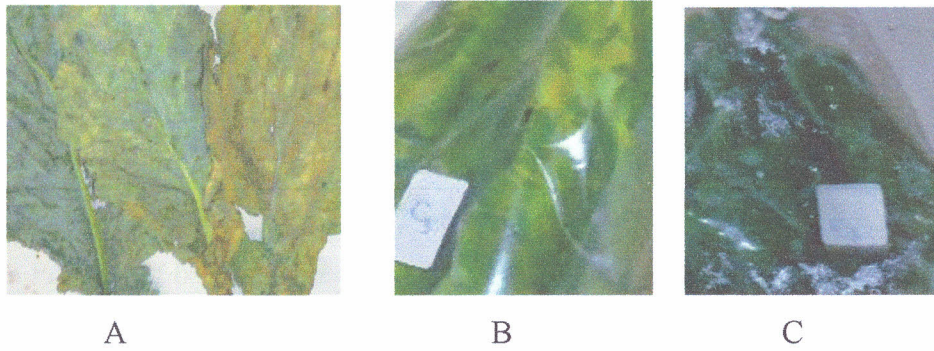


Fig 3.4 showing images of kales after storage in room for 4 days (A= Not packed, B =packed in Perforated and C=Packed in non-perforated polythene bag).

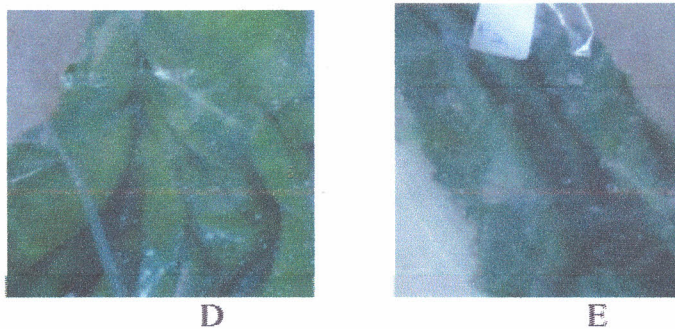


Fig 3.5 showing images of kales after storage in a refrigerator for 12 days (D=Packed in perforated, E = Packed in non-Perforated polythene bag)

3.2.3 Beta carotene content

Beta carotene decline in the stored samples was experienced with the least decline being in the packaged kales especially those stored in non-perforated polythene bag. This reduced decline was due to modified atmosphere inside the package thus reducing beta carotene oxidation. Beta carotene content of samples packed in non-perforated polythene bags and stored at room temperature for 6 days represents 12.3% while those in the refrigerator for 12 days represents 24.3 % of the amount found in freshly harvested kales.

Sample treatment	Initial B-carotene mg/100g (dwb)	Day when Attained color score 3	B-carotene Content mg/100g (dwb)
Washed with non-chlorinated water and packed in Non perforated bag	23.83	12	5.80
Washed with non-chlorinated water and packed in Perforated bag	23.83	10	2.04
Washed with chlorinated water and packed in Non Perforated bag	23.83	12	5.78
Washed with Chlorinated water and packed in Perforated bag	23.83	10	2.08

Table 3.3 showing initial and final beta carotene content of packaged samples that were refrigerated.

3.2.4 Retained Ascorbic Acid.

There was decline in Ascorbic Acid content in the stored kales. Least decline rate was in the packaged samples especially those packaged in non-perforated polythene bags. Retained ascorbic acid content of samples packed in non-perforated polythene bags and stored at room temperature for 6 days represents 17.9%, while those in the refrigerator for 12 days represents 81.3 % of the amount found in freshly harvested kales.

Sample	Storage	Ascorbic Acid content (mg/100g (dwb))					
		DAY 0	DAY 2	DAY 4	DAY 6	DAY 8	DAY 12
Not packed	Room	787.41	134.58	75.58	-	-	-
Packed in Non Perforated	Room	787.41	202.27	235.69	140.66	-	-
Packed in Perforated	Room	787.41	343.91	80.78	-	-	-
Not packed	Refrigerator	787.41	580.44	333.87	253.79		-
Packed in Non Perforated	Refrigerator	787.41	760.41	723.07	708.93	680.67	640.45
Packed in Perforated	Refrigerator	787.41	747.41	702.22	618	590.22	520.24

Table 3.4 showing retained Ascorbic Acid in stored samples at different temperature

4.0 CONCLUSION

From these results it is concluded that washing with chlorinated water (2ppm) had no effect on shelf life of the fresh whole kales while packaging extends the shelf life of fresh whole kales. Kales that were not packed, packaged in non-perforated and perforated polythene bags and stored at room temperature had a shelf life of; 4, 6 and 4 days respectively while Kales which were not packaged, packaged in non-perforated and perforated polythene bags and stored in a refrigerator had a shelf life of 6, 12, 10 days respectively. These results show potential of polythene bag packaging in extending shelf life of fresh kales from 4 to 12 days.

5.0 RECOMMEDATION

- ❖ The same analysis can be done using different gauges of polythene bags
- ❖ Loss of green color was determined subjectively; objective method can be used in analyzing color loss.

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