

1           **EFFECTS OF PRETREATMENTS ON THE SHELF LIFE AND QUALITY OF**  
2           **CARROTS (*Daucus carota* subspecies sativus) STORED AT DIFFERENT**  
3           **TEMPERATURES**

4  
5   **ABSTRACT**

6   Carrot is one of the top ten most important vegetables in the world due to its nutritional contents  
7   however, it is highly perishable. One major way to extend its shelf life is to store in the  
8   refrigerator but these can only prolong the shelf life for only a few weeks. Therefore, there is the  
9   need to research into how the shelf life can be extended further. Fresh matured carrots bought  
10   from Shasha market in Akure, Ondo State, Nigeria were washed with potable water and grouped  
11   into 7; each group was subjected to different pretreatment except the 7<sup>th</sup> group that was left  
12   untreated. All the carrot groups were dried in sun for five hours and then packed aseptically into  
13   different sterile air tight polyethylene food bags (different bag for different group). Each group  
14   was replicated and one batch was stored in the refrigerator ( $4 \pm 2^{\circ}\text{C}$ ) while the other batch was  
15   stored at room temperature ( $30 \pm 2^{\circ}\text{C}$ ). At intervals of one week, the samples were monitored  
16   for presence of soft rot, wrinkle, weight loss etc. All carrots stored at  $30 \pm 2^{\circ}\text{C}$  got spoiled after  
17   first week of storage irrespective of the type of pretreatment they were subjected to. However,  
18   pretreated carrots stored at  $4 \pm 2^{\circ}\text{C}$  had their shelf life extended with those treated with moringa  
19   seed aqueous extract having the best result at 24<sup>th</sup> week. This work shows that moringa seed  
20   aqueous extract can be used to extend the shelf life of carrots stored in the refrigerator.

21  
22   **Keywords:** Carrots, pretreatments, storage temperature, shelf life, moringa seed aqueous extract

## 24 INTRODUCTION

25 Carrot (*Daucus carota* subsp. *Sativus* (Hoffm.) Schübl and G. Martens) is a root vegetable,  
26 usually orange in colour though purple, black, red, white and yellow cultivars exists [1,2]. This  
27 vegetable is classified as a perishable produce, that is, it can't be kept for a long time. The  
28 primary agents of spoilage of carrots are bacteria and molds [3]. These organisms can be  
29 introduced to the crop during growth in the field, during harvesting and post – harvest handling  
30 or during storage resulting in a colossal loss of the vegetable. Other causes of loss include  
31 naturally occurring enzymes and the spoilage caused by moisture and vermin [4] This loss may  
32 be as high as thirty to fifty percent in developing countries where adequate cold storage facilities  
33 are not available which is the major way of storing vegetables in developed countries. Apart  
34 from cold storage method, other ways of storing carrots especially at household level include  
35 microwaving, blanching and freezing, canning, pickling, drying, root cellar, storing in the sand  
36 or sand boxes and carrot can be left in the ground [5]. However, cold storage or any of these  
37 other methods have not been able to prolong the shelf life of carrots for more than few weeks [6].  
38 It therefore becomes imperative to research into additional ways of extending the shelf life of  
39 this vegetable. Conventionally, some chemicals such as vinegar, sodium hypochlorite;  
40 condiments such as salt (sodium chloride) and sweeteners such as sugar are normally used to  
41 reduce or remove microbial loads of ready to eat vegetables [7-9]. It therefore becomes of  
42 interest to investigate if these treatments can also be used to prolong the shelf life of carrots. This  
43 present research therefore is to investigate whether all these and natural products like *Moringa*  
44 *oleifera* which has been reported to have potent antibacterial activity against most bacterial  
45 species [10] can extend the shelf life of carrots.

46

47 **MATERIALS AND METHODS**

48 **Sample collection:** Fresh matured carrots in good shape (minimal damage) were purchased from  
49 Shasha market in Akure, Ondo State, Nigeria during the raining period April, 2016. They were  
50 kept in sterile polythene bag and then taken to Microbiology Research Laboratory at the Federal  
51 University of Technology, Akure, Nigeria (FUTA) for analyses.

52 **Preparation of different solutions used to wash the carrots**

53 **Brine preparation:** Sixty grams of sodium chloride was dissolved in 1 liter of sterile distilled  
54 water according to the method of Greger [11].

55 **Sugar solution preparation:** The method of Thompson [12] was strictly followed in which 5g  
56 of sugar was weighed and dissolved in 100g of sterile distilled water.

57 **Vinegar:** The vinegar used was a product of Food condiments Nigeria Limited, Ogun State,  
58 Nigeria (NAFDAC approved).

59 **Sodium hypochlorite:** This was prepared according to the method of Rutola [7]. Ten millilitre  
60 of 5% sodium hypochlorite was diluted in 1 liter of distilled water to obtain 0.05% sodium  
61 hypochlorite (mild concentration for food).

62 **Moringa seed aqueous extract:** This was prepared according to the method of Beth [10]. Seeds  
63 were aseptically removed from matured moringa seed pods and then decoat to obtain clean seed  
64 kernels. The seed kernels were crushed using sterile laboratory mortar and pestle to obtain a fine  
65 powder. The seed powder (468mg) was mixed with a small amount of sterile distilled water to  
66 form a paste which was further mixed with 250ml of sterile distilled water in a sterile bottle and  
67 shook for 1 minute to activate the coagulant properties and to form a solution. This solution was

68 filtered through a sterile muslin cloth to remove insoluble materials and kept in a sterile bottle for  
69 immediate use.

70 **Experimental design:** In this study the effects of different pretreatments and different storage  
71 temperatures on carrots storability was observed.

72 **Soaking of carrots in the different pretreatments:** The leafy part of the carrots were removed  
73 and the carrots were washed with potable water except those that served as control. The washed  
74 carrots were grouped into 7 (10 carrot sticks per group), the first group was soaked in sugar  
75 solution (5%) for 30 minutes, second group in sodium hypo chlorite (0.05%), the third group in  
76 vinegar (5% acetic acid), fourth group in brine (6.0%), fifth group in sterile distilled water, sixth  
77 group in moringa seed aqueous extract (468mg per 250ml (w/v)) while the 7<sup>th</sup> group was left  
78 untreated. All the carrot groups were dried in the sun for 5 hours and then packed aseptically into  
79 different sterile air tight polyethylene food bags (different bag for different group), according to  
80 World carrot museum (2018) [13].

81  
82 **Effects of different pretreatments on the storability of carrots at different temperatures:**  
83 Each group prepared above was replicated and one batch was stored in the refrigerator ( $4 \pm 2^{\circ}\text{C}$ )  
84 while the other batch was stored at room temperature ( $30 \pm 2^{\circ}\text{C}$ ). At intervals of one week, the  
85 samples were monitored for spoilage which was determined on the basis of change in texture due  
86 to microbial activity (soft rot), change in colour or unpleasant odour and weight loss. The carrots  
87 were kept dry by changing the damped plastic bag when necessary during the storage period.

#### 88 **Data analyses**

89 Data obtained were subjected to one-way analysis of variance (ANOVA) and Duncan's New  
90 Multiple Range Test at 95% confidence level.

91

92 **Percentage spoilage** =  $\frac{W1 - W2}{W1} \times 100$   
93  
94

95 **Key:**

96 W1= Total number of carrots packed per treatment

97 W2 = Number of spoilt carrots

98

99 **Percentage Weight loss** =  $\frac{\text{Original weight of sample} - \text{Final weight}}{\text{Original weight of sample}} \times 100$   
100  
101

102

## 103 **RESULTS**

104 **Effects of different pretreatments on the percentage of carrots that got spoilt during**  
105 **storage at refrigerator temperature ( $4 \pm 2^\circ\text{C}$ ) and room temperature ( $30 \pm 2^\circ\text{C}$ ):** The various  
106 pretreatments used were able to prolong the storability of carrots at refrigerator temperature ( $4 \pm$   
107  $2^\circ\text{C}$ ) except carrots pretreated with vinegar that got spoilt within the first week of storage having  
108 100% spoilage. Carrots pretreated with brine and sugar solution had spoilage percentages of 73.3  
109 and 53.3 respectively at 1<sup>st</sup> week of storage. At the end of the 2<sup>nd</sup> week of storage, carrots washed  
110 with brine, sugar solution and those not washed at all gave percentage spoilage of 93.3, 80.0 and  
111 46.7 respectively while those washed with moringa seed aqueous extract had 6.7% spoilage. At  
112 week 7, all carrots washed with the various pretreatments had over 50% spoilage except those  
113 washed with moringa seed aqueous extract having 40% spoilage. The rate of spoilage increased  
114 as the storage period increased. By the 36<sup>th</sup> week, only the carrots pretreated with moringa  
115 aqueous extract remained and this continued until 39<sup>th</sup> by which time all the carrots had got

116 spoiled (Table 1). Carrots stored on the bench at room temperature ( $30 \pm 2^\circ\text{C}$ ) on the other hand, all  
117 got spoiled after one week of storage irrespective of the pretreatments used (Table 2).

118

119 **Percentage weight loss of carrot stored at refrigerator temperature ( $4 \pm 2^\circ\text{C}$ ) and room**

120 **temperature ( $30 \pm 2^\circ\text{C}$ ) after different pretreatments:** The weight of the carrots stored at

121 refrigerator temperature ( $4 \pm 2^\circ\text{C}$ ) was stable within the first 2 weeks of storage, only carrots

122 pretreated with vinegar gave a weight loss of 9.14% at 1<sup>st</sup> week while those pretreated with brine

123 and sugar had a percentage weight loss of 10.77 and 6.80 respectively at the end of 2<sup>nd</sup> week.

124 Moreover, the weight of the carrots gradually reduced as it aged, by the 35<sup>th</sup> week carrots

125 pretreated with sterile distilled water, potable water, sodium hypochlorite and moringa seed

126 aqueous extract gave a percentage weight loss of 52.03, 54.40, 51.85 and 51.95 respective. At

127 39<sup>th</sup> week carrots pretreated with moringa seed aqueous extract had percentage weight loss of

128 54.00 (Table 3). Carrots stored on the bench on the other hand lost weight significantly from 1<sup>st</sup>

129 week ranging from 18.78% for unwashed carrots to 1.18% for carrots pretreated with moringa

130 aqueous extract which had the least weight loss. By the 2<sup>nd</sup> week of storage, the weight loss

131 increased to 34.40% for those that were not washed at all and 12.70% for those washed with

132 moringa seed aqueous extract. The least weight loss was observed in carrots washed with

133 moringa seed aqueous extract (Table 4).

134 **TABLE 1: Effects of different pretreatments on the percentage of carrots that got spoiled during storage at temperature  $4 \pm 2^{\circ}\text{C}$**

Week	UN	SS	SHC	B	SDW	M	V	PW
1	43.20±0.26 <sup>bcd</sup>	53.37±0.12 <sup>cd</sup>	20.53±0.46 <sup>abc</sup>	73.43±0.15 <sup>cd</sup>	20.53±0.46 <sup>abc</sup>	6.77±0.06 <sup>a</sup>	100.00±0.00 <sup>d</sup>	16.87±0.15 <sup>ab</sup>
2	46.20±0.44 <sup>abcd</sup>	80.40±0.35 <sup>cde</sup>	50.17±0.15 <sup>bcd</sup>	93.47±0.15 <sup>de</sup>	43.37±0.06 <sup>abc</sup>	6.83±0.15 <sup>a</sup>	100.00±0.00 <sup>e</sup>	20.53±0.50 <sup>ab</sup>
3	70.17±0.15 <sup>abc</sup>	90.33±0.35 <sup>bc</sup>	60.07±0.06 <sup>ab</sup>	100.00±0.00 <sup>c</sup>	70.00±0.10 <sup>abc</sup>	20.53±0.50 <sup>a</sup>	100.00±0.00 <sup>c</sup>	20.53±0.50 <sup>a</sup>
4	83.10±0.20 <sup>bcd</sup>	93.37±0.31 <sup>cd</sup>	76.63±0.31 <sup>abcd</sup>	100.00±0.00 <sup>d</sup>	73.37±0.12 <sup>abc</sup>	23.53±0.25 <sup>a</sup>	100.00±0.00 <sup>d</sup>	37.30±0.20 <sup>ab</sup>
5	83.10±0.20 <sup>abcd</sup>	93.37±0.31 <sup>cd</sup>	83.57±0.31 <sup>bcd</sup>	100.00±0.00 <sup>d</sup>	73.37±0.12 <sup>abc</sup>	30.07±0.21 <sup>a</sup>	100.00±0.00 <sup>d</sup>	43.43±0.23 <sup>ab</sup>
6	86.20±0.44 <sup>bcd</sup>	96.27±0.38 <sup>cd</sup>	83.57±0.31 <sup>abcd</sup>	100.00±0.00 <sup>d</sup>	73.37±0.12 <sup>abc</sup>	36.47±0.40 <sup>a</sup>	100.00±0.00 <sup>d</sup>	43.43±0.23 <sup>ab</sup>
7	86.20±0.44 <sup>bcd</sup>	96.27±0.38 <sup>cd</sup>	83.57±0.31 <sup>abcd</sup>	100.00±0.00 <sup>d</sup>	73.37±0.12 <sup>abc</sup>	40.17±0.15 <sup>a</sup>	100.00±0.00 <sup>d</sup>	50.17±0.21 <sup>ab</sup>
8	86.20±0.44 <sup>bcd</sup>	96.67±0.35 <sup>cd</sup>	83.57±0.25 <sup>abcd</sup>	100.00±0.00 <sup>d</sup>	73.27±0.15 <sup>abc</sup>	40.17±0.15 <sup>a</sup>	100.00±0.00 <sup>d</sup>	53.30±0.20 <sup>ab</sup>
9	86.20±0.44 <sup>bcd</sup>	96.67±0.35 <sup>cd</sup>	83.57±0.31 <sup>abcd</sup>	100.00±0.00 <sup>d</sup>	73.47±0.21 <sup>abc</sup>	40.17±0.15 <sup>a</sup>	100.00±0.00 <sup>d</sup>	53.30±0.20 <sup>ab</sup>
10	86.20±0.44 <sup>bcd</sup>	96.67±0.35 <sup>cd</sup>	83.43±0.12 <sup>abcd</sup>	100.00±0.00 <sup>d</sup>	73.47±0.21 <sup>abc</sup>	40.17±0.15 <sup>a</sup>	100.00±0.00 <sup>d</sup>	56.70±0.20 <sup>ab</sup>
11	90.27±0.25 <sup>bcd</sup>	96.67±0.35 <sup>cd</sup>	83.57±0.31 <sup>abcd</sup>	100.00±0.00 <sup>d</sup>	73.47±0.21 <sup>abc</sup>	43.50±0.20 <sup>a</sup>	100.00±0.00 <sup>d</sup>	60.20±0.17 <sup>ab</sup>
12	90.27±0.25 <sup>bcd</sup>	96.67±0.35 <sup>cd</sup>	83.63±0.31 <sup>abcd</sup>	100.00±0.00 <sup>d</sup>	73.47±0.21 <sup>abc</sup>	46.47±0.49 <sup>a</sup>	100.00±0.00 <sup>d</sup>	63.30±0.20 <sup>ab</sup>
13	90.27±0.25 <sup>bcd</sup>	96.67±0.35 <sup>cd</sup>	83.57±0.31 <sup>abcd</sup>	100.00±0.00 <sup>d</sup>	73.47±0.21 <sup>abc</sup>	50.00±0.20 <sup>a</sup>	100.00±0.00 <sup>d</sup>	63.30±0.20 <sup>ab</sup>
14	90.27±0.25 <sup>bcd</sup>	96.67±0.35 <sup>cd</sup>	83.57±0.31 <sup>abcd</sup>	100.00±0.00 <sup>d</sup>	73.47±0.21 <sup>abc</sup>	50.00±0.20 <sup>a</sup>	100.00±0.00 <sup>d</sup>	63.30±0.20 <sup>ab</sup>
15	90.27±0.25 <sup>bcd</sup>	96.67±0.35 <sup>cd</sup>	83.57±0.31 <sup>abcd</sup>	100.00±0.00 <sup>d</sup>	73.47±0.21 <sup>abc</sup>	50.00±0.20 <sup>a</sup>	100.00±0.00 <sup>d</sup>	63.30±0.20 <sup>ab</sup>
16	90.27±0.25 <sup>bcd</sup>	96.67±0.35 <sup>cd</sup>	83.57±0.31 <sup>abcd</sup>	100.00±0.00 <sup>d</sup>	73.47±0.21 <sup>abc</sup>	50.00±0.20 <sup>a</sup>	100.00±0.00 <sup>d</sup>	63.30±0.20 <sup>ab</sup>
17	90.27±0.25 <sup>bcd</sup>	96.67±0.35 <sup>cd</sup>	86.70±0.20 <sup>abcd</sup>	100.00±0.00 <sup>d</sup>	73.47±0.21 <sup>abc</sup>	53.20±0.26 <sup>a</sup>	100.00±0.00 <sup>d</sup>	70.27±0.25 <sup>ab</sup>
18	90.27±0.25 <sup>bcd</sup>	96.67±0.35 <sup>cd</sup>	86.70±0.20 <sup>abcd</sup>	100.00±0.00 <sup>d</sup>	73.47±0.21 <sup>abc</sup>	53.20±0.26 <sup>a</sup>	100.00±0.00 <sup>d</sup>	70.27±0.25 <sup>ab</sup>
19	90.27±0.25 <sup>bcd</sup>	96.67±0.35 <sup>cd</sup>	86.63±0.12 <sup>abcd</sup>	100.00±0.00 <sup>d</sup>	73.47±0.21 <sup>abc</sup>	53.20±0.26 <sup>a</sup>	100.00±0.00 <sup>d</sup>	70.27±0.25 <sup>ab</sup>
20	90.27±0.25 <sup>bcd</sup>	96.67±0.35 <sup>cd</sup>	86.70±0.20 <sup>abcd</sup>	100.00±0.00 <sup>d</sup>	76.83±0.12 <sup>abc</sup>	56.80±0.10 <sup>a</sup>	100.00±0.00 <sup>d</sup>	73.43±0.15 <sup>ab</sup>
21	90.27±0.25 <sup>bc</sup>	96.67±0.35 <sup>bc</sup>	86.70±0.20 <sup>abc</sup>	100.00±0.00 <sup>c</sup>	76.83±0.12 <sup>ab</sup>	56.80±0.10 <sup>a</sup>	100.00±0.00 <sup>c</sup>	76.83±0.12 <sup>ab</sup>
22	90.27±0.25 <sup>bc</sup>	96.67±0.35 <sup>bc</sup>	86.70±0.20 <sup>abc</sup>	100.00±0.00 <sup>c</sup>	76.77±0.12 <sup>ab</sup>	60.33±0.35 <sup>a</sup>	100.00±0.00 <sup>c</sup>	76.83±0.12 <sup>ab</sup>
23	90.27±0.25 <sup>bcd</sup>	96.67±0.35 <sup>cd</sup>	86.70±0.20 <sup>abcd</sup>	100.00±0.00 <sup>d</sup>	83.50±0.20 <sup>abc</sup>	66.70±0.20 <sup>a</sup>	100.00±0.00 <sup>d</sup>	76.83±0.12 <sup>ab</sup>
24	93.37±0.12 <sup>bcd</sup>	96.67±0.35 <sup>cd</sup>	86.70±0.20 <sup>abcd</sup>	100.00±0.00 <sup>d</sup>	83.50±0.20 <sup>abc</sup>	66.70±0.20 <sup>a</sup>	100.00±0.00 <sup>d</sup>	80.43±0.38 <sup>ab</sup>
25	100.00±0.00 <sup>b</sup>	100.00±0.00 <sup>b</sup>	86.70±0.20 <sup>ab</sup>	100.00±0.00 <sup>b</sup>	83.50±0.20 <sup>ab</sup>	73.30±0.20 <sup>a</sup>	100.00±0.00 <sup>b</sup>	80.43±0.38 <sup>a</sup>
26	100.00±0.00 <sup>b</sup>	100.00±0.00 <sup>b</sup>	86.70±0.20 <sup>ab</sup>	100.00±0.00 <sup>b</sup>	83.50±0.20 <sup>ab</sup>	73.30±0.20 <sup>a</sup>	100.00±0.00 <sup>b</sup>	80.43±0.38 <sup>a</sup>
27	100.00±0.00 <sup>b</sup>	100.00±0.00 <sup>b</sup>	86.70±0.20 <sup>ab</sup>	100.00±0.00 <sup>b</sup>	83.50±0.20 <sup>ab</sup>	73.30±0.20 <sup>a</sup>	100.00±0.00 <sup>b</sup>	80.43±0.38 <sup>a</sup>
28	100.00±0.00 <sup>b</sup>	100.00±0.00 <sup>b</sup>	93.27±0.25 <sup>ab</sup>	100.00±0.00 <sup>b</sup>	83.50±0.20 <sup>ab</sup>	73.30±0.20 <sup>a</sup>	100.00±0.00 <sup>b</sup>	80.43±0.38 <sup>a</sup>
29	100.00±0.00 <sup>b</sup>	100.00±0.00 <sup>b</sup>	93.27±0.25 <sup>ab</sup>	100.00±0.00 <sup>b</sup>	83.50±0.20 <sup>ab</sup>	73.30±0.20 <sup>a</sup>	100.00±0.00 <sup>b</sup>	80.43±0.38 <sup>a</sup>
30	100.00±0.00 <sup>b</sup>	100.00±0.00 <sup>b</sup>	93.27±0.25 <sup>ab</sup>	100.00±0.00 <sup>b</sup>	83.50±0.20 <sup>a</sup>	80.07±0.06 <sup>a</sup>	100.00±0.00 <sup>b</sup>	83.50±0.20 <sup>a</sup>
31	100.00±0.00 <sup>b</sup>	100.00±0.00 <sup>b</sup>	93.27±0.25 <sup>ab</sup>	100.00±0.00 <sup>b</sup>	90.17±0.21 <sup>ab</sup>	83.50±0.20 <sup>a</sup>	100.00±0.00 <sup>b</sup>	86.83±0.12 <sup>a</sup>
32	100.00±0.00 <sup>b</sup>	100.00±0.00 <sup>b</sup>	93.27±0.25 <sup>ab</sup>	100.00±0.00 <sup>b</sup>	90.17±0.21 <sup>a</sup>	83.50±0.20 <sup>a</sup>	100.00±0.00 <sup>b</sup>	90.17±0.21 <sup>a</sup>
33	100.00±0.00 <sup>b</sup>	100.00±0.00 <sup>b</sup>	93.27±0.25 <sup>ab</sup>	100.00±0.00 <sup>b</sup>	93.23±0.31 <sup>ab</sup>	86.63±0.31 <sup>a</sup>	100.00±0.00 <sup>b</sup>	90.17±0.21 <sup>a</sup>
34	100.00±0.00 <sup>b</sup>	100.00±0.00 <sup>b</sup>	100.00±0.00 <sup>b</sup>	100.00±0.00 <sup>b</sup>	100.00±0.00 <sup>b</sup>	86.63±0.31 <sup>a</sup>	100.00±0.00 <sup>b</sup>	90.17±0.21 <sup>a</sup>
35	100.00±0.00 <sup>b</sup>	100.00±0.00 <sup>b</sup>	100.00±0.00 <sup>b</sup>	100.00±0.00 <sup>b</sup>	100.00±0.00 <sup>b</sup>	86.53±0.21 <sup>a</sup>	100.00±0.00 <sup>b</sup>	96.87±0.15 <sup>a</sup>
36	100.00±0.00 <sup>b</sup>	100.00±0.00 <sup>b</sup>	100.00±0.00 <sup>b</sup>	100.00±0.00 <sup>b</sup>	100.00±0.00 <sup>b</sup>	90.27±0.25 <sup>a</sup>	100.00±0.00 <sup>b</sup>	100.00±0.00 <sup>b</sup>
37	100.00±0.00 <sup>b</sup>	100.00±0.00 <sup>b</sup>	100.00±0.00 <sup>b</sup>	100.00±0.00 <sup>b</sup>	100.00±0.00 <sup>b</sup>	90.27±0.25 <sup>a</sup>	100.00±0.00 <sup>b</sup>	100.00±0.00 <sup>b</sup>
38	100.00±0.00 <sup>b</sup>	100.00±0.00 <sup>b</sup>	100.00±0.00 <sup>b</sup>	100.00±0.00 <sup>b</sup>	100.00±0.00 <sup>b</sup>	90.27±0.25 <sup>a</sup>	100.00±0.00 <sup>b</sup>	100.00±0.00 <sup>b</sup>
39	100.00±0.00 <sup>a</sup>	100.00±0.00 <sup>a</sup>	100.00±0.00 <sup>a</sup>	100.00±0.00 <sup>a</sup>	100.00±0.00 <sup>a</sup>	100.00±0.00 <sup>a</sup>	100.00±0.00 <sup>a</sup>	100.00±0.00 <sup>a</sup>

135 Treatments with the same alphabet along the row are not significantly different at  $P < 0.05$

136 **KEY:** UN: UNWASHED SS: SOAKED IN SUGAR SOLUTION SHC: SOAKED IN SODIUM HYPO CHLORITE B: SOAKED IN BRINE V: SOAKED IN VINEGAR

137 SDW: WASHED WITH STERILE DISTILLED WATER M: SOAKED IN MORINGA SEED AQUEOUS EXTRACT PW: WASHED WITH POTABLE WATER

138 V: SOAKED IN VINEGAR PW= WASHED WITH POTABLE WATER

139 **Table 2: Percentage of carrots that got spoiled during storage at temperature  $30 \pm 2^\circ\text{C}$**   
 140 **after different pretreatments.**

141

Percentage (%) of spoilt carrots		
Pretreatments	Week 1	Week 2
Washed with potable water	25.13±0.12 <sup>a</sup>	100.00±0.00 <sup>a</sup>
Soaked in sugar solution	26.67±0.35 <sup>ab</sup>	100.00±0.00 <sup>a</sup>
Soaked in brine	33.30±0.20 <sup>abc</sup>	100.00±0.00 <sup>a</sup>
Soaked in moringa seed aqueous extract	33.30±0.20 <sup>abc</sup>	100.00±0.00 <sup>a</sup>
Washed with sterile distilled water	50.13±0.12 <sup>bcd</sup>	100.00±0.00 <sup>a</sup>
Soaked in sodium hypochlorite	76.20±0.20 <sup>cd</sup>	100.00±0.00 <sup>a</sup>
Soaked in vinegar	83.27±0.25 <sup>cd</sup>	100.00±0.00 <sup>a</sup>
Untreated	100.00±0.00 <sup>d</sup>	100.00±0.00 <sup>a</sup>

142 Treatments with the same alphabet along the row are not significantly different at  $P < 0.05$   
 143  
 144



145 **Table 3: Percentage weight loss of carrot stored at refrigerator temperature ( $4 \pm 2^{\circ}\text{C}$ ) after**  
 146 **different pretreatments**

147  
 148

Percentage (%) weight loss of stored carrots

Time interval (week)	UN	SS	SHC	B	SDW	M	V	PW
1	0.0	0.0	0.0	0.0	0.0	0.0	9.14	0.0
2	0.0	6.8	0.0	10.8	0.0	0.0	ACS	0.0
3	1.7	10.7	0.0	13.9	1.4	0.3	ACS	0.0
4	2.6	15.6	0.0	ACS	2.8	2.5	ACS	5.7
5	5.9	24.0	0.0	ACS	3.0	3.6	ACS	9.3
6	7.0	25.1	0.5	ACS	5.4	12.7	ACS	14.4
7	7.0	28.3	15.8	ACS	6.5	12.7	ACS	17.9
8	13.0	29.2	18.5	ACS	6.5	20.7	ACS	21.5
9	17.7	31.1	18.5	ACS	8.7	25.0	ACS	24.8
10	19.4	35.6	18.5	ACS	10.0	27.0	ACS	25.3
11	21.0	37.3	19.1	ACS	10.0	27.6	ACS	26.9
12	23.4	43.8	19.5	ACS	16.1	30.3	ACS	29.9
13	26.5	45.4	19.8	ACS	19.4	33.8	ACS	30.0
14	38.8	46.6	23.9	ACS	23.7	34.8	ACS	30.3
15	40.0	48.9	26.3	ACS	27.3	35.5	ACS	32.3
16	43.0	49.4	29.3	ACS	27.6	36.2	ACS	33.6
17	43.7	49.8	29.7	ACS	27.7	36.5	ACS	33.8
18	45.4	50.5	31.2	ACS	27.8	38.8	ACS	34.3
19	45.8	53.1	32.9	ACS	29.3	40.0	ACS	36.9
20	45.8	53.3	35.5	ACS	29.3	40.9	ACS	37.9
21	45.8	53.3	34.2	ACS	30.1	41.4	ACS	38.9
22	48.5	53.4	34.2	ACS	32.2	42.0	ACS	41.1
23	50.1	58.8	34.3	ACS	32.6	42.7	ACS	41.7
24	54.4	59.2	34.4	ACS	33.1	42.9	ACS	42.0
25	59.2	60.8	44.4	ACS	34.2	43.1	ACS	43.4
26	ACS	ACS	45.7	ACS	34.8	43.8	ACS	43.9
27	ACS	ACS	46.8	ACS	34.8	45.3	ACS	46.8
28	ACS	ACS	46.9	ACS	34.8	47.2	ACS	47.0
29	ACS	ACS	47.1	ACS	36.0	48.1	ACS	47.9
30	ACS	ACS	47.3	ACS	38.5	49.4	ACS	48.4
31	ACS	ACS	47.7	ACS	44.7	50.0	ACS	48.9
32	ACS	ACS	48.3	ACS	45.7	50.9	ACS	50.1
33	ACS	ACS	49.7	ACS	47.0	51.1	ACS	51.3
34	ACS	ACS	51.2	ACS	49.7	51.5	ACS	53.1
35	ACS	ACS	51.9	ACS	52.0	52.0	ACS	54.4
36	ACS	ACS	ACS	ACS	ACS	52.7	ACS	56.2
37	ACS	ACS	ACS	ACS	ACS	52.7	ACS	ACS
38	ACS	ACS	ACS	ACS	ACS	53.0	ACS	ACS
39	ACS	ACS	ACS	ACS	ACS	54.0	ACS	ACS

149 Key: ACS = All carrots gotspoiled; UN= Unwashed; SS= Soaked in sugar solution; SHC= soaked in sodium hypochlorite; B= Soaked in brine;  
 150 SDW= Soaked in sterile distilled water; M= Soaked in moringa seed aqueous extract; V= soaked in vinegar; PW= soaked in potable water  
 151  
 152

153  
 154 **Table 4: Percentage weight loss carrot stored at room temperature ( $30 \pm 2^{\circ}\text{C}$ ) after the**  
 155 **different pretreatments**

Percentage (%) of weight loss carrots

Pretreatments	Week 1	Week 2
Unwashed	18.78	34.40
Soaked in sugar solution	1.34	15.63
Soaked in sodium hypochlorite	3.16	18.40
Soaked in brine	1.92	13.85
Soaked in sterile distilled water	10.50	20.04
Soaked in moringa seed aqueous extract	1.18	12.70
Soaked in potable vinegar	2.59	15.76
Soaked in potable water	1.29	14.38

158  
 159

## 160 **DISCUSSION**

161 In this study, the effect of different pretreatments on the keeping quality of carrots stored at two  
162 different temperatures was investigated. Carrots kept in the refrigerator (temperature  $4 \pm 2^{\circ}\text{C}$ )  
163 had its shelf life extended as compared with those stored on bench at room temperature ( $30 \pm$   
164  $2^{\circ}\text{C}$ ). This agree with the findings of Ernest [14], Grai [15] and Mateljan [16] that carrots can be  
165 stored for up to a month in the coolest place in the refrigerator if properly prepared for storage. It  
166 also agrees with the documentation of Soonchye [6] and MacDonald [5] that proper control of  
167 temperature and relative humidity are key to maximizing storage of vegetables because they are  
168 subjected to respiration, water loss and cell softening after harvest. From this study it was  
169 discovered that in addition to refrigeration that extended the shelf of carrots, pretreatment of  
170 carrots with the different solutions used further extended the shelf life of this vegetable except  
171 those that were pretreated with vinegar. The inability of vinegar to extend the shelf life might be  
172 due to the fact that vinegar contains acetic acid (5%) which has a burning effect on plant  
173 products. The acetic acid of vinegar is reported to dissolve the cell membranes resulting in  
174 desiccation of tissues [17]. The observation that carrots pretreated with moringa seed aqueous  
175 extract stored at  $4 \pm 2^{\circ}\text{C}$  had the lowest percentage spoilage throughout the period of the study  
176 showed that it can be exploited to prolong the storage of carrots when kept at this temperature.  
177 The preservation mediated by moringa seed aqueous extract might be as a result of its hydrative  
178 effect in addition to its known antibacterial activity [18].

179

## 180 **CONCLUSION**

181 This study had been able to show that carrots washed with moringa seed aqueous extract stored  
182 longer in the refrigerator than carrots subjected to other pretreatments. *Moringa oleifera* has been

183 known for its antibacterial properties but it has not been explored in food preservation. It is  
184 therefore suggested that carrots should be washed with moringa seed aqueous extract before  
185 storing in refrigerator to prolong its shelf life.

186

## 187 REFERENCES

188 1. Arscott, S. A., Simon, P. W. and Tanumiharjo, S. A. (2010). Anthocyanins in purple-orange  
189 carrots (*Daucus carota* L.) do not influence the bioavailability of Beta-carotene in young  
190 women. *Journal of Agric Food Chemistry* 58(5): 2877-81. doi: 10.1021/jf9041326.

191 2. Megan, W. (2017). What are the health benefits of carrots. Medical news today, 5<sup>th</sup> December,  
192 2017. [www.medicalnewstoday.com](http://www.medicalnewstoday.com)

193 3. Onuorah, S., Nriagu, O., Obika, I. (2016). Isolation, characterization and identification of  
194 microorganisms from spoilt carrots obtained from Ose market Onisha, Nigeria. *Universal*  
195 *Journal of Biomedical Engineering* 4(1): 6-9. Doi: 10.13189/ujbe.2016.040102

196 4. Garg, H. P. and Prakash (2000). Solar energy. Fundamentals and applications. Tata McGraw-  
197 Hill Education p191. ISBN 978-0-07-463631-2

198 5. Macdonald, Mark (2017). How to Store Carrots – West Coast Seed. Article and Instruction,  
199 Garden Resources, Vegetable Talk. Bookmark the Permalink, [www.westcoastseeds.com/garden-](http://www.westcoastseeds.com/garden-resources.../how-to-store-carrots/)  
200 [resources.../how-to-store-carrots/](http://www.westcoastseeds.com/garden-resources.../how-to-store-carrots/)

201 6. Soonchye, T. (2016). Storage of fresh fruit and vegetables. Department of primary industries  
202 and regional development. Agriculture and Food WA Government Search.  
203 <https://agric.wa.gov.au/n/2978>.

204 7. Rutola, W. (1996). Use of disinfectants. *American Journal of Infection Control* 24(4): 313-342

- 205 8. Rutola, W.A; Barbee, S.L; Aguiar, N.C; Sobsey, M.D; Weder D.J. (2000). Antimicrobial  
206 activity of home disinfectants and natural products against potential human pathogens. *Infection*  
207 *Control and Hospital Epidemiology*21 (1): 33-38.<https://doi.org/10.1086/501694>
- 208 9. Yadav, K. Y. and Satya, V. S. (2014). Osmotic Dehydration of Fruits and Vegetables: A  
209 Review. *Journal of Food Science and Technology* 51(9): 1654-73. Doi: 10.1007/s13197-012-  
210 0659-2
- 211 10. Beth, D. (2005). Moringa water treatment. An ECHO technical note. Diet and Nutritional  
212 Medicine. Random House Digital. P.97. ISBN 978-1-60774-507-5.
- 213 11. Greger, M.D. (2015). How to make your own fruit and vegetable wash. Health and Nutrition  
214 volume 24 p 2. [Nutritionalfacts.org](http://Nutritionalfacts.org)
- 215 12. Thompson, D. (2018). How to make 20% sugar solution. Sciencing. <https://sciencing.com>
- 216 13. World Carrot Museum (2018). How to store carrot.  
217 [www.carrotmuseum.co.uk/carrotstorage.html](http://www.carrotmuseum.co.uk/carrotstorage.html)
- 218 14. Ernest, D. (2007). How to store fresh carrots. Vegetable gardening, Dorling Kindersleydiy  
219 network News letter. [www.diynetwork.com](http://www.diynetwork.com)
- 220 15. Grai I. (2018). How to plant, grow and harvest carrots. The old farmer's almanac.  
221 <https://www.almanac.com>plant>carrots>
- 222 16. Mateljan, George (2018). The World's Healthiest Foods. What's new and beneficial about  
223 Carrots. [www.whfoods.com/genpage](http://www.whfoods.com/genpage).
- 224 17. Grant, A. (2018). Benefits of vinegar: how to use Vinegar in the garden.  
225 <https://www.gardeningknowhow.com>

226 18. Lar, P. M; Ojile, E. E; Dashe, E. and Oluoma, J. N. (2011). Antibacterial activity of *Moringa*  
227 *oleifera* seed extracts on some Gram negative bacterial isolates. *African Journal of Natural*  
228 *Sciences* 14: 57 – 62. ISSN: 1119-1104  
229

UNDER PEER REVIEW