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

ABSTRACT

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

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

INTRODUCTION

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

MATERIALS AND METHODS

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

Preparation of different solutions used to wash the carrots

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

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

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

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

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

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

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

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

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

Data analyses

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

$$\text{Spoilage percentage} = \frac{W1 - W2}{W1} \times 100$$

Key:

W1= Total number of carrots packed per treatment

W2 = Number of spoilt carrots

$$\text{Weight loss percentage} = \frac{\text{original weight of sample} - \text{final weight}}{Original\ weight\ of\ sample} \times 100$$

RESULTS

Effects of different pretreatments on the percentage of carrots that got spoilt during storage at refrigerator temperature (4 ± 2^{o}C) and room temperature (30 ± 2^{o}C): The various pretreatments used were able to prolong the storability of carrots at refrigerator temperature (4 ± 2 ^{o}C) except carrots pretreated with vinegar that got spoilt within the first week of storage having 100% spoilage. Carrots pretreated with brine and sugar solution had spoilage percentages of 73.3 and 53.3 respectively at 1st week of storage. At the end of the 2nd week of storage, carrots washed with brine, sugar solution and those not washed at all gave percentage spoilage of 93.3, 80.0 and 46.7 respectively while those washed with moringa seed aqueous extract had 6.7% spoilage. At week 7, all carrots washed with the various pretreatments had over 50% spoilage except those

112 washed with moringa seed aqueous extract having 40% spoilage. The rate of spoilage increased
113 as the storage period increased. By the 36th week, only the carrots pretreated with moringa
114 aqueous extract remained and this continued until 39th by which time all the carrots had got
115 spoilt (Table 1). Carrots stored on the bench at room temperature (30± 2^{o}C) on the other hand, all
116 got spoilt after one week of storage irrespective of the pretreatments used (Table 2).
117
118 **Percentage weight loss of carrot stored at refrigerator temperature (4 ± 2^{o}C) and room**
119 **temperature (30 ± 2^{o}C) after different pretreatments:** The weight of the carrots stored at
120 refrigerator temperature (4 ± 2^{0}C) was stable within the first 2 weeks of storage, only carrots
121 pretreated with vinegar gave a weight loss of 9.14% at 1st week while those pretreated with brine
122 and sugar had a percentage weight loss of 10.77 and 6.80 respectively at the end of 2nd week.
123 Moreover, the weight of the carrots gradually reduced as it aged, by the 35th week carrots
124 pretreated with sterile distilled water, potable water, sodium hypochlorite and moringa seed
125 aqueous extract gave a percentage weight loss of 52.03, 54.40, 51.85 and 51.95 respective. At
126 39th week carrots pretreated with moringa seed aqueous extract had percentage weight loss of
127 54.00 (Table 3). Carrots stored on the bench on the other hand lost weight significantly from 1st
128 week ranging from 18.78% for unwashed carrots to 1.18% for carrots pretreated with moringa
129 aqueous extract which had the least weight loss. By the 2nd week of storage, the weight loss
130 increased to 34.40% for those that were not washed at all and 12.70% for those washed with
131 moringa seed aqueous extract. The least weight loss was observed in carrots washed with
132 moringa seed aqueous extract (Table 4).

TABLE 1: Effects of different pretreatments on the percentage of carrots that got spoiled during storage at temperature 4 ± 2°C

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

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

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

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

V: SOAKED IN VINEGAR PW= WASHED WITH POTABLE WATER

Table 2: Percentage of carrots that got spoiled during storage at temperature 30 ± 2^{o}C after different pretreatments.

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

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

Table 3: Percentage weight loss of carrot stored at refrigerator temperature (4 ± 2°C) after different pretreatments

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

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

Table 4: Percentage weight loss carrot stored at room temperature (30 ± 2°C) after the 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 inmoringa seed aqueous extract	1.18	12.70
Soaked in potable vinegar	2.59	15.76
Soaked in potable water	1.29	14.38

DISCUSSION

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

CONCLUSION

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

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

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