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Research Article

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Effects of Prestorage Heat Treatment on Ripening, Firmness and Sensory Quality of Cucumber (*Cucumis Sativus L*) Fruits

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Abstract

Much work on heat treatment of fruits targeted decay control without investigating the effect of the heat on ripening, firmness and sensory quality. Hence, this research work is designed to investigate the effects of heat treatment on these post-harvest traits of cucumber fruits. A set of disinfected cucumber fruits were separately treated with Hot Water (HW) and hot air (HA) at 40/50°C for 10, 20, 30 minutes. Untreated fruits served as control. Both fruits were then stored in sterilized desiccators at 28 ± 2°C and 75 ± 5% RH and observed daily for peel color change while firmness and sensory quality observed by day 40 in storage. Generally, 100% greenness indicated by peel color values between 1.00 ± 0.000 and 1.67 ± 0.333 was observed by day 40 in storage for fruits treated with HW at 40°C-10 mins, 40°C-30mins and 50°C- 20 mins, HA at 40/50oC for 20 mins. Besides, these treated fruits were firmer and more accepted (higher scores) than the control. Therefore, HW treatments at 40°C - 10mins, 40°C-30mins and 50°C-20 mins and HA treatments at 40 / 50oC-20 mins harvest proved most effective in retaining the complete greenness of the fruits with overall sensory acceptability till day 40 in storage and could thus be recommended for treating and extending the shelf life of the fruits after harvest.

Keywords: Appearance, Hot air, Hot water, Peel color, Shelf life, Taste

Introduction

Cucumber *(Cucumis sativus L)* belongs to the family cucurbitaceous and is one of the oldest cultivated fruits which originated from Southern Asia and the fourth most widely cultivated crop after tomato, cabbage and onion [1-2]. In fact, Cucumbers are popular, nutritional and one of the most important fruits in tropical and subtropical area of the world [3]. Botanically, it is classified as a type of berry with a hard outer rind and no internal divisions. Much like tomato and squash, it is often prepared and eaten as a vegetable [4]. Nutritionally the edible portion of cucumber contains 2.7% carbohydrates, 0.4% mineral matter and 96.9% water [5]. The fruits of cucumber are laxative, astringent, anthelmintic and antipyretic; useful in hepatitis, bronchitis, asthma, dyspepsia, piles, diarrhea, coughs hoarseness of voice, eye diseases and used as a hair tonic. Decoction of the green fruit is used for cough. The pulp of fruit is useful in dysenteric-diarrhea, dropsy, piles and leprosy [6].

However, like many cucurbit crops, cucumber is prone to a number of fungal diseases which cause serious economic losses to the crop and common among such fungal diseases is black rot of cucumber caused by Aspergillus Niger. Meanwhile, the major strategies for the control of postharvest diseases are by spraying with fungicides, use of botanicals, heat treatment, irradiations, waxing of the fruits and use of plant extracts [7]. For fungicide and wax treatment, poisoning of the fruits due to chemical residue has been one of the limitations [8]. Irradiation has also been found expensive to use and continuous exposure leads to cancer. Hence, the need for non-chemical controls measure. Interestingly, during the past few years there has been increasing interest in the use of heat treatments to control insect pests, prevent fungal rots and affect the ripening or response to temperature extremes of the commodity. Part of this interest is because there is a growing demand to decrease the postharvest use of chemicals against pathogens and insects.

Consequently, heat treatment substitutes a non-damaging physical treatment for chemical prevention and has several advantages: it is simple to apply, safe and ecofriendly. It can be applied in the form of dry hot air, humid hot air or in the form of hot water [8]. Heat treatments have been applied to firm potatoes, tomatoes, carrots and strawberries; to preserve the colour of asparagus, broccoli, green beans, kiwi fruits, celery and lettuce; to prevent development of overripe flavours in cantaloupe and other melons; and to generally add to the longevity of grapes, plums, bean sprouts and peaches, among others [9]. In fact, a number of previous reviews have dealt with specialized aspects of heat treatments but with little or no work on the effect of heat treatment as it affect ripening of cucumber fruits. More so, many authors who studied the effects of post-harvest heat treatments did so with the sole aim of controlling or reducing post-harvest decay during storage without investigating the effect of such treatments on the ripening, firmness and sensory quality of such fruits [10-16].

Thus, it is against this background that this research work is designed to investigate the effects of heat treatment as it affects these post-harvest traits of cucumber *(Cucumis sativus L)* fruits.

Materials and Methods

This research work was conducted in Storage Microbiology Laboratory of Biology, School of Science, Federal University of Technology, Akure, and Nigeria.

Source of cucumber fruits: Mature, green healthy cucumber fruits were harvested from Shagari village Akure, Ondo State on Longitude 5°11'E and Latitude 7°17'N. Fruits of uniform size and colour were selected. Before treatment, the fruits were washed with clean water, disinfected for 10 minutes in 0.385% m/v of sodium hypochlorite and allowed to air-dry at 26°C.

Heat treatment

A set of the disinfected cucumber fruits were immersed inside hot

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water bath (CU–420) at the following Hot Water Treatment (HWT) regimes: 40°C for 10, 20, 30 minutes and 50°C for 10, 20, 30 minutes with each treatment lot consisting of five fruits while untreated fruits served as control. Both treated and control fruits were then stored in sterilized desiccators at 28 ± 2°C and 75 ± 5% relative humidity and observed daily for peel colour change (ripening). The same procedure was repeated for another set of the fruits treated with Hot Air (HA) in a hot air oven at the same temperature–time regimes.

Visual assessment for peel colour change

The treated fruits were observed daily during storage for peel colour change by visual assessment and observation was ranked using the hedonic scale of but with slight modification where 1 = 100% green; 2 = 75% green / 25% yellow; 3 = 50% green / 50% yellow; 4 = 75% yellow / 25% green and 5 = 100% yellow [17]. To obtain a weighted average for the colour change, the number of fruits with each colour rating was multiplied by the rating and divided by the number of fruits.

Firmness test

Fruits from each treatment which retained the complete greenness of the fruits till day 40 in storage were tested for firmness using fruit penetrometer (GY-3 model). The penetrometer was put on the fruit uprightly, pressed into the fruit and stopped when its plunger entered into the fruit and the observed value was recorded.

Sensory evaluation of cucumber fruits

Sensory evaluation of fruits which retained the complete greenness of the fruits till day 40 in storage was done by an informal panel of ten judges. Fruits samples from each effective treatment were labeled and laid out for the panel of judges to avoid biased judgment. Appearance index was determined by scoring graded fruit as very good / no sign of wilting on the entire fruit surface (4); good / no sign of wilting up to 90% of the fruit (3); showing sign of wilting up to 45% of the fruit (2) or wilted (1) [18]. Wiltness was evident by light brown coloration or appearance of mycelium on the fruit surface.

Data analysis

Results were expressed as the mean ± standard error of five replicates. The data obtained were subjected to Analysis of Variance (ANOVA) using the statistical analysis system. Where applicable, the means were then separated by Turkey HSD test at a 5% level of significance.

Results

The peel colour values of control and all cucumber fruits treated with HW Table 1 was not significantly affected ($p > 0.05$) for the first 15days in storage. The peel colour values were between 1.00 ± 0.000 and 1.67 ± 0.333 for both the control and all the treated fruits indicating they were 100% green. The same trend of results was also observed from day 20 even till day 40 in storage for fruits treated at 40°C-10mins, 40°C-30 mins and 50°C-20 mins, maintaining peel colour values of 1.00 ± 0.000 (40°C-10mins), 1.33 ± 0.333 (40°C-30 mins) and 1.67 ± 0.333 (50°C – 20 mins). Other treated fruits were however significantly different ($p < 0.05$). The peel colour values on day 20 of fruits treated at 40°C - 20mins (2.33 ± 0.333) and 50°C – 20 mins (2.67 ± 0.333) indicating 75% green and 25% yellow, were not significantly different from each other but significantly different ($p < 0.05$) from fruits treated at 50°C-30 mins (5.00 ± 0.000) and the control (5.00 ± 0.000) which indicated 100% yellow. The same trend was observed for fruits treated at 40°C – 20 mins (2.33 ± 0.333) and 50°C-20 mins (2.67 ± 0.333) on day 25 while the peel colour values of fruits treated at 50°C-10 mins and the control could not be determined because of high fungal decay. Meanwhile fruits treated at 40°C-10 mins and 50°C-30 mins maintained peel colour values of 4.67 ± 0.577 (25% green and 75% yellow) and 5.00 ± 0.000 (100% yellow) respectively. Furthermore, the peel colour values of all cucumber fruits treated with HA was not significantly affected ($p > 0.05$) for the first 15 days in storage. The peel colour values ranged from 1.00 ± 0.000 to 1.67 ± 0.333 which implied that all the treated fruits were 100% green. The same trend of result (100% greenness) was observed for day 20 in all the treated fruits except that the peel colour values of fruits treated at 50°C – 30 mins and the control had increased significantly to 3.00 ± 0.557 (5% green and 50% yellow) and 5.00 ± 0.000 (100% yellow) respectively. Also, 100% greenness was still observed from days 25 to 40 in storage for fruits (Table 1).

Values are means of five replicates ± standard error of mean. Figures followed by the same letter within the same olumns not significantly different by Tukey's HSD Test ($p > 0.05$). 1 = 100% green; 2 = 75% green and 25% yellow; 3 = 50% green and 50% yellow, 4 = 25% green and 75% yellow and 5 = 100% yellow; could not be determined (Table 2).

Values are means of five replicates ± standard error of mean. Figures followed by the same letter within the same columns are not significantly different by Tukey's HSD Test ($p > 0.05$). 1 = 100% green; 2 = 75% green and 25% yellow; 3 = 50% green and 50% yellow, 4 = 25% green and 75% yellow and 5 = 100% yellow; - could not be determined.

Treated at 40°C-20 mins and 50°C-20 mins only, with both treatments maintaining peel colour values of 1.00 ± 0.000 on day 25 and the value increased though not significantly to 1.33 ± 0.333 on day 40.

Table 1: Effect of hot water treatment on peel colour change of cucumber (*Cucumis sativus L*) fruits stored at 28 ± 2°C and 75 ± 5% relative humidity.

Hot Water Treatments (°C-mins)							
Storage Duration (Days)				**Peel colour values**			
40-10	40-20	40-30	50-10	50-20		50-30	Control
5	1.00 ± 0.000^{a}	1.00 ± 0.000^{a}	1.00 ± 0.000^{a}	1.00 ± 0.000^{a}	1.67 ± 0.333^{a}	1.33 ± 0.333^{a}	1.00 ± 0.000^{a}
10	1.00 ± 0.000^{a}	1.00 ± 0.000^{a}	1.00 ± 0.000^{a}	1.00 ± 0.000^{a}	1.67 ± 0.333^{a}	1.67 ± 0.333^{a}	1.00 ± 0.000^{a}
15	1.00 ± 0.000^{a}	1.00 ± 0.000^{a}	1.00 ± 0.000^{a}	1.00 ± 0.000^{a}	1.67 ± 0.333^{a}	1.67 ± 0.333^{a}	1.67 ± 0.667^{a}
20	1.00 ± 0.000^{a}	2.33 ± 0.333^{b}	1.33 ± 0.333^{a}	2.67 ± 0.333^{b}	1.67 ± 0.333^{a}	5.00 ± 0.000^{c}	5.00 ± 0.000^{c}
25	1.00 ± 0.000^{a}	2.33 ± 0.333^{b}	1.33 ± 0.333^{a}	-	1.67 ± 0.333^{a}	5.00 ± 0.000^{c}	-
30	1.00 ± 0.000^{a}	4.67 ± 0.577^{b}	1.33 ± 0.333^{a}	-	1.67 ± 0.333^{a}	5.00 ± 0.000^{c}	-
35	1.00 ± 0.000^{a}	4.67 ± 0.577^{b}	1.33 ± 0.333^{a}	-	1.67 ± 0.333^{a}	5.00 ± 0.000^{c}	-
40	1.00 ± 0.000^{a}	4.67 ± 0.577^{b}	1.33 ± 0.333^{a}	-	1.67 ± 0.333^{a}	5.00 ± 0.000^{c}	-

Table 2: Effect of hot air treatment on peel colour change of cucumber (*Cucumis sativus L*) fruits stored at 28 ± 2°C and 75 ± 5% relative humidity.

Storage Duration (days)	Hot air treatments (°C-mins)						
	Peel colour values						
	40-10	40-20	40-30	50-10	50-20	50-30	Control
5	1.00 ± 0.000^{a}	1.00 ± 0.000^{a}	1.00 ± 0.000^{a}	1.00 ± 0.000^{a}	1.00 ± 0.000^{a}	1.00 ± 0.000^{a}	1.00 ± 0.000^{a}
10	1.00 ± 0.000^{a}	1.00 ± 0.000^{a}	1.00 ± 0.000^{a}	1.00 ± 0.000^{a}	1.00 ± 0.000^{a}	1.00 ± 0.000^{a}	1.00 ± 0.000^{a}
15	1.00 ± 0.000^{a}	1.00 ± 0.000^{a}	1.00 ± 0.000^{a}	1.00 ± 0.000^{a}	1.00 ± 0.000^{a}	1.67 ± 0.333^{a}	1.67 ± 0.667^{a}
20	1.33 ± 0.333^{a}	1.00 ± 0.000^{a}	1.00 ± 0.000^{a}	1.00 ± 0.000^{a}	1.00 ± 0.000^{a}	3.00 ± 0.577^{b}	5.00 ± 0.000^{c}
25	2.00 ± 0.000^{ab}	1.00 ± 0.000^{a}	2.33 ± 0.333^{b}	5.00 ± 0.000^{c}	1.00 ± 0.000^{a}	5.00 ± 0.000^{c}	-
30	3.00 ± 0.577^{b}	1.33 ± 0.333^{a}	5.00 ± 0.000^{c}	5.00 ± 0.000^{c}	1.00 ± 0.000^{a}	5.00 ± 0.000^{c}	-
35	4.67 ± 0.333^{c}	1.33 ± 0.333^{a}	5.00 ± 0.000^{c}	5.00 ± 0.000^{c}	1.33 ± 0.333^{a}	5.00 ± 0.000^{c}	-
40	5.00 ± 0.000^{c}	1.33 ± 0.333^{a}	5.00 ± 0.000^{c}	5.00 ± 0.000^{c}	1.33 ± 0.333^{a}	5.00 ± 0.000^{c}	-

Table 3: Firmness of cucumber fruits following treatment with HW and HA that retained the complete greenness of the fruits till day 40 in storage at 28 ± 2°C and 75 ± 5% relative humidity.

HW (°C – mins)	Firmness (kgcm^{-3})	HA (°C mins)	Firmness (kgcm^{-3})
Before treatment	7.80 ± 0.200a	Before treatment	7.80 ± 0.200a
40 – 10	7.64 ± 0.276a	40 – 20	7.85 ± 0.255a
40 – 30	7.69 ± 0.349a	50 – 20	7.87 ± 0.770a
Values are means of five replicates ± standard error of mean. Figures followed by the same letter within the same columns are not significantly different by Tukey's HSD Test (p > 0.05).			

Similarly, the firmness (kgcm^{-3}) of fruits before treatment (7.80 ± 0.200) was not significantly different (p > 0.05), though higher, than the firmness of HW treated fruits at 40°C-10 mins (7.64 ± 0.276), 40°C-30 mins (7.61 ± 0.349) and 50°C-20 mins (7.75 ± 0.255) and lower but not significantly different (p > 0.05) from the firmness of HA treated fruits at 40°C-20 mins (7.85 ± 0.255) and 50°C-20 mins (7.87 ± 0.770). On the basis of the average scores given by the judges, the appearance index values of fruits which retained complete greenness by day 40 in storage following HWT at 40°C for 10 minutes (3.33 ± 0.333), 40°C for 30 minutes (3.44 ± 0.440) and 50°C for 20 minutes (3.56 ± 0.630/1.56 ± 0.360) and HAT at 40°C for 20 minutes (3.45 ± 0.245) and 50°C for 20 minutes (3.13 ± 0.291) showed that the treated fruits were still good when compared with the control fruits with appearance values of 1.29 ± 0.900, indicating wilted and inedible fruits.

Discussion

The observed 100% greenness of the treated cucumber fruits when compared with the control fruits on day 40 in storage confirmed that the yellow colour development of cucumber fruits was delayed and this must have been aided by the stated hot water temperatures and exposure times described above. This observation is buttressed by previous research of [19,20] that hot water treatment retard post-harvest physiological changes that could lead to ripening in fruits/ In fact, report of [21] who studied the effect of hot water treatment on quality of cucumber concluded that use of hot water as a general treatment in postharvest was more effective (Table 3).

Values are means of five replicates ± standard error of mean. Figures followed by the same letter within the same columns are not significantly different by Tukey's HSD Test (p > 0.05) (Table 4).

For maintaining the quality of cucumber interestingly, these experimented hot water temperatures and exposure times in this work aside from maintaining complete greenness till day 40 in storage also preserved the fruits against decay. This variation in colour development is also the view of that external damage by heat is generally peeled browning or yellowing of fruits particularly in

Table 4: Appearance index values of cucumber fruits following treatment with HW and HA that retained the complete greenness of the fruits till day 40 in storage at 28 ± 2°C and 75 ± 5% relative humidity.

HW (°C – mins)	Appearance	HA (°C – mins)	Appearance
40-10	3.33 ± 0.333	40-20	3.45 ± 0.240
40-30	3.44 ± 0.440	50-20	3.13 ± 0.290
50-20	3.56 ± 0.630		
Control	1.29 ± 0.900	Control	1.29 ± 0.900
Each value is a mean of 10 replicates.			

cucumber [22]. Several authors have earlier reported that chlorophyll degradation leading to chlorophyll loss is one of the major issues in many post-harvest horticultural produces resulting to yellowing and senescence [23,24]. Likewise, reported though on citruses, that the yellow development in citrus is a result of decline in the chlorophyll content of the rind [25]. Also, the claim that the loss of chlorophyll as a result of conversion from chloroplast to chromoplast was supported by which unmasks the various coloured compounds principally carotenoids which increase during ripening of fruits [26]. This observation is buttressed by some earlier reports that heat treatment retarded ripening related colour changes [27-30].

The beneficial effects of these heat treatments are linked through changes in physiological processes such as a reduction in chilling injury and delay of ripening processes by heat inactivation of degradative enzymes [31] and since heat treatments slow down their ripening process, it is reasonable to see a delay in full colour development with heat treatments duration [32]. This is also buttressed by the reports of that high temperatures ≥ 40°C prevent the accumulation of carotenoids synthesis [33]. The mechanism by which a heat treatment causes change in ripening of fruit such as inhibition of ethylene synthesis and cell wall degrading enzymes may be tied to changes in the gene expression and protein synthesis. It was further reported that during a high temperature, the mRNA of fruits ripening disappeared and those of heat shock protein accumulates [34]. Other treated fruits however showed varying peel colour values that were significantly different (p > 0.05) and ranged from 2.00 ± 0.000 (75% green and 25% yellow) in fruits treated at 40°C – 10 mins on day 25

to 5.00 ± 0.000 (100% yellow) in fruits treated at 40°C for 10, 30 mins and 50°C for 10, 30 mins on day 40.

Also, observation on firmness is in agreement with the previous works of who reported similar findings on mango fruits with HW treated fruits having lower firmness while HA treated fruits had higher firmness and were not significantly affected as compared with untreated fruits [35]. The observed firmness of the treated fruits might be attributed to antifungal activity of the effective HA and HW which resultantly must have reduced infection, respiration and other ripening processes in the treated fruits. This implied that the treated samples were more accepted (higher scores) than the control fruits. This is buttressed by the reports of that treating cucumber *(Cucumis sativus L.)* with short hot-water immersion at 45 and 55°C gave the best appearance, colour and taste during storage when compared with the control fruits [21]. Similar findings though on carrot juice, were observed by that all juice samples pasteurized at 90°C recorded higher overall acceptability [36]. In fact, the quality of fresh-cut fruits and vegetables can be maintained by physical treatment without affecting their external and internal quality parameters [37].

Conclusion

During the past few years there has been increasing interest in the use of heat treatments to control insect pests, prevent fungal rots and affect the ripening or response to temperature extremes of the commodity. Remarkably in this work, fruits treated with hot water at 40°C-10mins, 40°C – 30 mins and 50°C-20mins and with hot air at 40°C- 20 mins and 50°C-20 mins proved most effective in retaining the complete greenness of the fruits with overall sensory acceptability even till day 40 while in storage and could therefore be used in treating and extending the shelf life of the cucumber fruits.

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Conflict of interest

The authors hereby declare that there is no conflict of interest.

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