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Effect of Drumstick Tree (*Moringa oleifera*) and Neem (*Azadirachta indica*) Leaf Powders on Shelf Life and Physiological Quality of Okra Fruits during Storage

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ABSTRACT

Healthy okra fruits of some varieties; clemson spineless and stubby okra were obtained from the experimental farm at Apir, Makurdi at harvest stage. The experiment was a 2 x 3 factorial combination of treatments, fitted in a completely randomized design and replicated three times. The okra fruits were coated with *Moringa oleifera* and *Azadirachta indica* leaf powders and stored at room temperature. Data collected were subjected to Analysis of Variance (ANOVA) using GENSTAT statistical package, and Fisher's Least Significant Difference (F-LSD) at a 5%. Results showed significant differences in the parameters studied. For example, stubby okra produced significantly higher weight loss than clemson spineless on days 12 and 15 of storage. *Moringa oleifera* produced significantly lowest weight loss while the highest weight loss was obtained with untreated okra. Significant differences in firmness was also observed within the varieties at days 3, 6, 9 and 12 as clemson spineless produced the highest firmness of okra fruit while stubby okra recorded the lowest. *Moringa oleifera* produced the highest firmness value across all days while the control gave the lowest firmness value. The highest titratable acidity content among the okra varieties was produced by clemson spineless on all days of storage. Untreated okra generally gave higher titratable acidity values on all days. *Moringa oleifera* produced significantly lower titratable acidity on all days. Stubby okra gave higher total soluble solids value on day 3. *Moringa oleifera* gave the highest total soluble solids value while *Azadirachta indica* and untreated (control) produced similar values which represented the lowest total soluble solids value. The vitamin C content of stored okra was significantly higher with stubby okra as compared to clemson spineless. *Moringa oleifera* produced higher vitamin C content at days 3, 9, 12 and 15 and the difference was significant, while untreated okra recorded the lowest vitamin C content on all days of storage. *Moringa oleifera* also gave the highest pH value on all days. Control gave the lowest pH value and this was significantly lower than that produced by *Azadirachta indica*. The shelf life of the treated okra fruits ranged from days 1-15 while the control ranged from 1-7 days. The temperature of the storage room ranged from 27.1 – 29.9^0C and the relative humidity ranged from 29.5 – 44.5%. It is concluded that leaf powders of *Moringa oleifera* and *Azadirachta indica* enhanced the shelf life and physiological quality of okra during storage. The phytochemical analysis of these botanicals used in the study revealed the presence or absence of active compounds such as steroids, glycosides, saponins, alkaloids, carbohydrates, flavonoids, cardiac glycosides, tannins and phenols, and anthraquinones. These botanicals are environmentally friendly, cost-effective, easy to produce and easy to apply formulations and are also safe for consumers. *Moringa oleifera* and *Azadirachta indica* leaf powders are recommended in the storage of fresh okra most especially the clemson spineless okra variety.

Keywords: Moringa; Neem; Leaf Powders; okra; shelf life

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1.0 INTRODUCTION

Okra (*Abelmoschus esculentus* L. Moench) belongs to the *Malvaceae* family and is the second most important vegetable in the West African market after tomatoes. It is one of the most commonly grown vegetable crops in the Tropics.

Nigeria is the second largest producer of okra in the world and the largest producer in Africa. Nigeria has experienced a tremendous wastage of okra of about 38% recently (Farinde, *et al.*, 2006), this has led to huge economic losses to the farmers, traders, and the entire economy of the Country. Katende (2006) had reported that fresh okra fruits are perishable and even when stored at the temperature of 7^0C to 10^0C, its shelf life is only 7 to 10 days. This huge wastage is due to a lack of adequate shelf life extension techniques for okra. Some of the farmers and traders are aware of the need to preserve okra. However, they are ignorant of the most suitable preservative method to use. For instance, most of the farmers/traders use synthetic chemicals preserve okra (Farinde *et al.* 2007). Furthermore, synthetic chemicals are harmful to the environment and their chemical residues may be found on the fruit which are dangerous to the health of the users (Obeng-Ofori and Sackey, 2003).

The concept of using plant leaf powders as coatings to extend the shelf life of fresh produce and protect them from harmful environmental effects has been emphasized based on the need for high-quality fruits and storage technologies (Tharanathan, 2003). An ideal coating/film is defined as one that can extend the storage life of fresh fruit without causing anaerobosis and reduces decay without affecting negatively the quality of the fruit. Therefore, the objective of this research is to study the effect of *Moringa oleifera* and *Azadirachta indica* leaf powders as coatings /films on the changes in physiological parameters related to okra quality during storage and its role in extending the shelf life of the fruits.

2.0 MATERIALS AND METHODS

The experiment was carried out in the Botany laboratory of the Benue State University, Makurdi. Healthy okra fruits of some varieties; clemson spineless and stubby okra were carefully harvested at breaker stage by hand picking from the experimental farm. The fruits were carefully placed in plastic crates and taken to the laboratory for further studies.

Fresh leaves of *Moringa oleifera* (Drumstick tree) and *Azadirachta indica* (Neem) were collected from different locations in Makurdi metropolis. A cutlass was used to cut branches while the leaves were harvested by handpicking. The leaves were put in clean polythene bags

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and taken to the laboratory. In the laboratory, the leaves of each plant were first prewashed carefully under a gentle stream of tap water for one to two minutes to remove surface dirt. This was followed by washing in sterile distilled water containing 1% sodium hypochloride for thirty seconds. The leaves were then removed and rinsed in three successions of sterile distilled water. The disinfected plant leaves were air dried on the laboratory bench for 7 - 9 days after which they were ground into fine powder first, with mortar and pestle and then with a blender. The powders of each plant were stored separately in well covered clean jars and kept in a dust free locker.

Firm, smooth and healthy okra fruits of the two varieties were washed in clean water to remove dirt and kept to air dry before treatment. The okra fruits were coated / treated by dipping them in the powders of each plant species. The fruits were removed and arranged on wooden racks in plastic crates and kept at room temperature.

The experiment was a 2 x 3 factorial combination of treatments, fitted in a completely randomized design (CRD), replicated three times. The okra fruits were treated with plant leaf powders of *Moringa oleifera* (Drumstick tree) and *Azadirachta indica* (Neem). No application of *Moringa oleifera* (Drumstick tree) and *Azadirachta indica* (Neem) served as control. This constituted 6 treatment combinations, 3 per variety. This was replicated three times, which give 18 treatment units and each unit contained 17 fruits. The total number of fruits used in the experiment was 306 okra fruits.

Okra fruits were then placed on a digital weighing balance and each reading was recorded throughout the storage period. Other data collected included firmness, titratable acid, total soluble solids, Vitamin C/Ascorbic acid content, pH, shelf life, temperature and relative humidity.

3.0 RESULTS

The effect of variety on weight loss of okra fruits during storage showed that stubby okra obtained significantly the highest fruit weight loss as compared to clemson spineless at 12 and 15 days of storage (Table 1). Among the plant leaf powders, the highest weight loss of okra fruits during storage was obtained with untreated (control) fruits while *Moringa oleifera* (Drumstick tree) produced the lowest weight loss across the days evaluated. The interaction of variety and plant leaf powders on weight loss of okra fruits in storage was not significant (Table 2). Stubby okra with no application (untreated) consistently gave the highest fruit weight loss in all the days. Clemson spineless produced lower fruit weight loss when it was

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treated with *Moringa oleifera* (Drumstick tree) in all the days of storage. Generally, irrespective of the variety, fruits treated with *Moringa oleifera* (Drumstick tree) obtained the lowest weight loss and there was progressive decrease in weight loss of okra fruits in all the days of storage (Table 1).

Table 1: Main Effect of Variety and Plant Leaf Powders on the Weight Loss (g) of Okra Fruits during Storage

	Days of Storage				
Variety	**DAY 3**	**DAY 6**	**DAY 9**	**DAY 12**	**DAY 15**
Clemson spineless	71.75	59.08	42.11	23.72	12.41
Stubby okra	73.12	59.78	43.44	25.71	13.69
F-LSD (P≤0.05)	NS	NS	NS	1.73	1.00
Treatments					
Moringa	66.79	54.26	39.71	22.59	11.84
Neem	74.06	59.49	42.39	24.58	13.15
Control	76.51	64.55	46.22	26.98	14.12
F-LSD (P≤0.05)	3.82	3.42	2.63	2.12	1.22

Table 2: Interactive Effect of Variety and Plant Leaf Powders on the Weight loss (g) of Okra Fruit during Storage

		Days of Storage				
Variety	**Treatments**	**DAY 3**	**DAY 6**	**DAY 9**	**DAY 12**	**DAY 15**
Clemson spineless	*Moringa*	66.28	54.01	39.14	21.72	10.80
	Neem	73.27	59.60	42.00	24.34	12.88
	Control	75.71	63.62	45.21	25.10	13.55
Stubby okra	*Moringa*	67.30	54.51	40.30	23.46	12.89
	Neem	74.86	59.37	42.80	24.82	13.42
	Control	77.32	65.48	47.23	28.87	14.77
F-LSD (P≤0.05)		NS	NS	NS	NS	NS

The varietal effect on okra firmness showed that clemson spineless variety of okra produced the highest firmness value as compared to stubby okra which obtained the lowest firmness of okra at 3, 6, 9 and 12 days of storage and significant difference was observed. At day 15, clemson spineless obtained higher firmness of okra to stubby okra but no significant difference was obtained. On days 3, 9 and 12, the main effect of variety and plant leaf powders was significant ($P < 0.05$) as *Moringa oleifera* (Drumstick tree) significantly produced the highest firmness value followed by *Azadirachta indica* (Neem) but the untreated okra fruit recorded the lowest firmness of okra fruit during storage. On days 6 and 15, the main effect of variety was not significant ($P > 0.05$), however okra fruits treated with

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Moringa oleifera (Drumstick tree) obtained higher firmness value of okra. The firmness of okra as influenced by the interaction effect of variety and plant leaf powders showed no significant difference (P> 0.05) across the days evaluated. Clemson spineless treated with *Moringa oleifera* (Drumstick tree) produced the highest firmness value across the days of evaluation as compared to those produced by stubby okra and this was not significant different as shown in Table 4.

Table 3: Main Effect of Variety and Plant Leaf Powders on the Firmness of Okra Fruit during Storage

	Firmness				
Variety	**DAY 3**	**DAY 6**	**DAY 9**	**DAY 12**	**DAY 15**
Clemson spineless	2.07	1.53	0.83	0.42	0.02
Stubby okra	1.83	1.28	0.55	0.28	0.00
F-LSD (P≤0.05)	0.01	0.15	0.10	0.09	NS
Treatments					
Moringa	2.10	1.53	0.85	0.50	0.03
Neem	1.90	1.33	0.63	0.28	0.00
Control	1.83	1.38	0.60	0.28	0.00
F-LSD (P≤0.05)	0.07	NS	0.13	0.12	NS

Table 4: Interaction Effect of Variety and Plant Leaf Powders on the Firmness of Okra Fruit

Variety	**Treatments**	**DAY 3**	**DAY 6**	**DAY 9**	**DAY 12**	**DAY 15**
Clemson spineless	*Moringa*	2.20	1.65	1.00	0.55	0.05
	Neem	2.05	1.45	0.80	0.35	0.00
	Control	1.95	1.50	0.70	0.35	0.00
Stubby okra	*Moringa*	2.00	1.40	0.70	0.45	0.00
	Neem	1.75	1.20	0.45	0.20	0.00
	Control	1.70	1.25	0.50	0.20	0.00

Okra varieties also showed significant difference on the titratable acidity (TA) of okra fruits during storage as clemson spineless produced the highest titratable acidity when compared with stubby okra at days 3, 6, 9 and 12 of storage and the difference was significant (Table 5). The highest titratable acidity content was significantly produced with clemson spineless when it was untreated. Generally, *Moringa oleifera* (Drumstick tree) plant leaf powders obtained lower titratable acidity regardless of the varieties. However, stubby okra treated with *Moringa oleifera* (Drumstick tree) recorded the lowest titratable acidity of okra fruits during storage which was significant at day 6, 9 and 12 but was not significant at day 3 and 15 during storage.

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Table 5: Main Effect of Variety and Plant Leaf Powders on the Titratable Acidity of Okra Fruits during Storage

	TTA				
Variety	**DAY 3**	**DAY 6**	**DAY 9**	**DAY 12**	**DAY 15**
Clemson spineless	0.21	0.29	0.39	0.49	0.58
Stubby okra	0.16	0.22	0.31	0.47	0.56
F-LSD (P≤0.05)	0.01	0.01	0.01	0.01	NS
Treatments					
Moringa	0.17	0.22	0.32	0.44	0.51
Neem	0.19	0.25	0.35	0.49	0.58
Control	0.20	0.29	0.39	0.51	0.62
F-LSD (P≤0.05)	0.01	0.01	0.02	0.01	0.02

Table 6: Interaction Effect of Variety and Plant Leaf Powders on the Titratable Acidity Content of Okra Fruits during Storage

Variety	**Treatments**	**DAY 3**	**DAY 6**	**DAY 9**	**DAY 12**	**DAY 15**
Clemson spineless	*Moringa*	0.19	0.24	0.38	0.47	0.53
	Neem	0.21	0.29	0.39	0.50	0.59
	Control	0.22	0.34	0.40	0.52	0.62
Stubby okra	*Moringa*	0.14	0.19	0.26	0.41	0.50
	Neem	0.16	0.22	0.31	0.48	0.57
	Control	0.19	0.25	0.37	0.51	0.62

In the case of the total soluble solids (TSS), stubby okra variety significantly produced the highest total soluble solids while clemson spineless obtained lowest total soluble solids from okra fruits during storage (Table 7). Okra fruits treated with *Moringa oleifera* (Drumstick tree) significantly produced the highest total soluble solids as compared to other plant leaf powders while *Azadirachta indica* (Neem) and untreated obtained the same value which represents the lowest total soluble solids (Table 8).

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Table 7: Main Effect of Variety and Plant Leaf Powders on the Total Soluble Solids (TSS) of Okra Fruit during Storage

	Total Soluble Solids (TSS)				
Variety	**DAY 3**	**DAY 6**	**DAY 9**	**DAY 12**	**DAY 15**
Clemson spineless	1.43	1.00	-	-	-
Stubby okra	1.63	1.00	-	-	-
F-LSD (P≤0.05)	0.09	NS	-	-	-
Treatments					
Moringa	1.65	1.00	-	-	-
Neem	1.48	1.00	-	-	-
Control	1.48	1.00	-	-	-
F-LSD (P≤0.05)	0.10	NS	-	-	-

Table 8: Interaction Effect of Variety and Plant Leaf Powders on the Total Soluble Solids (TSS) of Okra Fruit

Variety	**Treatments**	**DAY 3**	**DAY 6**	**DAY 9**	**DAY 12**	**DAY 15**
Clemson spineless	*Moringa*	1.45	1.00	-	-	-
	Neem	1.40	1.00	-	-	-
	Control	1.45	1.00	-	-	-
Stubby okra	*Moringa*	1.85	1.00	-	-	-
	Neem	1.55	1.00	-	-	-
	Control	1.50	1.00	-	-	-
F-LSD (P≤0.05)		0.15	NS	-	-	-

Similarly, for the effect of variety and plant leaf powders on Vitamin C content of okra during storage, stubby okra produced significantly the highest vitamin C content of the fruits across all the days of evaluation while the lowest vitamin C content was obtained with clemson spineless okra during the storage period (Table 9).

Table 9: Main Effect of Variety and Plant Leaf Powders on the Vitamin C of Okra Fruit during Storage

	VITAMIN C				
Variety	**DAY 3**	**DAY 6**	**DAY 9**	**DAY 12**	**DAY 15**
Clemson spineless	14.74	14.07	13.28	12.43	11.55
Stubby okra	18.59	17.81	17.12	16.13	15.19
F-LSD (P≤0.05)	0.11	0.24	0.16	0.18	0.13
Treatments					
Moringa	16.83	16.12	15.35	14.51	13.96
Neem	16.72	15.93	15.20	14.24	13.16
Control	16.45	15.78	15.06	14.08	12.99
F-LSD (P≤0.05)	0.14	NS	0.20	0.21	0.15

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Table 10: Interaction Effect of Variety and Plant Leaf Powders on the Vitamin C of Okra Fruits during Storage

Variety	Treatments	DAY 3	DAY 6	DAY 9	DAY 12	DAY 15
Clemson spineless	*Moringa*	14.89	14.22	13.43	12.70	12.14
	Neem	14.79	14.02	13.24	12.38	11.35
	Control	14.56	13.96	13.16	12.19	11.15
Stubby okra	*Moringa*	18.78	18.01	17.27	16.31	15.78
	Neem	18.65	17.84	17.15	16.11	14.96
	Control	18.35	17.60	16.96	15.96	14.83
F-LSD (P≤0.05)		0.11	0.21	NS	0.20	NS

Storage duration and treatments made okra to be slightly acidic and the difference due to treatment effect and storage duration was significant (Table 11). The results revealed that the effect of variety on pH of okra fruits during storage was significantly different as stubby okra obtained higher pH values as compared to clemson spineless. Similarly, the pH values of okra decreases steadily from days 3 to 15. For plant leaf powders, okra fruits coated with *Moringa oleifera* (Drumstick tree) powder significantly produced the highest pH value at day 3 followed by *Azadirachta indica* (Neem) while the untreated fruits obtained the lowest pH values of okra fruits at day 15 (Table 11). Irrespective of the okra variety, fruits coated with *Moringa oleifera* (Drumstick tree) gave the highest pH value (Table 12).

Table 11: Main Effect of Variety and Plant Leaf Powders on pH of Okra Fruit during Storage

	pH				
Variety	**DAY 3**	**DAY 6**	**DAY 9**	**DAY 12**	**DAY 15**
Clemson spineless	6.52	6.44	6.37	6.27	6.16
Stubby okra	6.61	6.50	6.42	6.29	6.18
F-LSD (P≤0.05)	0.01	0.01	0.02	0.02	NS
Treatments					
Moringa	6.59	6.50	6.42	6.31	6.24
Neem	6.57	6.47	6.40	6.29	6.15
Control	6.54	6.44	6.36	6.25	6.11
F-LSD (P≤0.05)	0.02	0.01	0.02	0.02	0.03

F-LSD – Fisher's Least Significant Difference at 5% level of Probability; NS – Not Significant

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Table 12: Interaction Effect of Variety and Plant Leaf Powders on pH of Okra Fruit during Storage

Variety	Treatments	DAY 3	DAY 6	DAY 9	DAY 12	DAY 15
Clemson spineless	*Moringa*	6.55	6.47	6.39	6.30	6.20
	Neem	6.52	6.44	6.37	6.28	6.16
	Control	6.50	6.40	6.34	6.23	6.11
Stubby okra	*Moringa*	6.64	6.54	6.45	6.32	6.27
	Neem	6.61	6.50	6.43	6.29	6.15
	Control	6.57	6.47	6.38	6.27	6.12
F-LSD (P≤0.05)		NS	NS	NS	NS	NS

F-LSD – Fisher's Least Significant Difference at 5% level of Probability; NS – Not Significant at 5% level of probability

Finally, shelf life of okra during storage was also investigated. The effect of variety and plant leaf powders as well as the interaction effect of variety and plant leaf powders on the shelf life of okra on days 3, 6, 9, 12 and 15 was not significantly different ($P \geq 0.05$). The shelf life of treated okra fruits increased from days 1 to 15 while the controls ranged from days 1 to 7, but no significant differences were observed between the treatments as shown in Tables 13 and 14.

Table 13: Main Effect of Variety and Plant Leaf Powders on the Shelf Life of Okra Fruit during Storage

	Shelf Life				
Variety	**DAY 3**	**DAY 6**	**DAY 9**	**DAY 12**	**DAY 15**
Clemson spineless	3.00	6.00	9.00	12.00	15.00
Stubby Okra	3.00	6.00	9.00	12.00	15.00
F-LSD (P≤0.05)	NS	NS	NS	NS	NS
Treatments					
Moringa	3.00	6.00	9.00	12.00	15.00
Neem	3.00	6.00	9.00	12.00	15.00
Control	3.00	6.00	7.00	7.00	7.00
F-LSD (P≤0.05)	NS	NS	NS	NS	NS

F-LSD – Fisher's Least Significant Difference at 5% level of Probability, NS – Not Significant

Table 14: Interaction Effect of Variety and Plant Leaf Powder on the Shelf Life of Okra Fruit

Variety	Treatments	DAY 3	DAY 6	DAY 9	DAY 12	DAY 15
Clemson spineless	*Moringa*	3.00	6.00	9.00	12.00	15.00
	Neem	3.00	6.00	9.00	12.00	15.00
	Control	3.00	6.00	7.00	7.00	7.00
Stubby	*Moringa*	3.00	6.00	9.00	12.00	15.00

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	Neem	3.00	6.00	9.00	12.00	15.00
	Control	3.00	6.00	7.00	7.00	7.00
F-LSD (P≤0.05)		NS	NS	NS	NS	NS

4.0 Discussion

Okra fruits both treated and untreated showed a decreased in weight during the storage period. However, the untreated fruits showed the highest weight loss compared with the treated fruits. *Moringa oleifera* (Drumstick tree) treated okra showed the lowest loss in weight followed by *Azadirachta indica* (Neem) treated samples. The control samples showed the highest weight loss generally implied that the leaf powders were effective in minimizing weight loss, which improved shelf life. This is in agreement with the finding of Liamngee *et al.*, (2018) that plant leaf powder of Moringa, Neem and Bitter leaf was an effective coating which served as a physical barrier and thus reduced weight loss and lowered the respiration rate of tomatoes during postharvest storage.

Okra fruits treated with *Moringa oleifera* (Drumstick tree) were firmer compared to those treated with *Azadirachta indica* (Neem). However, the untreated okra fruits showed firmness similar to the *Azadirachta indica* (Neem) treated fruits, firmness of okra fruits decreased generally during storage at ambient conditions. Reports by Meseret *et al.* (2012) and Liamngee *et al.* (2018) showed that firmness of fruits decreases with increased in storage period, as observed with the current study.

Okra fruits treated with *Azadirachta indica* (Neem) and *Moringa oleifera* (Drumstick tree) had no significant effect on the TA of the okra fruits. Wijewardane and Guleria (2013) had reported a decline in TA for stored apples coated with Neem oil.

This study revealed TSS of the untreated fruits recorded a faster decline than the treated fruits. This finding agreed with Liamngee *et al.* (2018), who reported a decrease in TSS of tomato fruits coated with Neem and Moringa powders during storage.

The vitamin C content was higher in okra treated with leaf powder and lower in the untreated fruits. Stubby okra showed a visibly higher concentration of vitamin C as compared to clemson spineless okra for both treated and untreated okra fruits.

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Treated and untreated okra fruits showed similar pH values indicating that the treatments did not show significant response on the pH of okra fruits during storage. Laila *et al.,* (2018) recorded a decrease of 1.02 % in pH by the twelfth week for okra coated with nanoparticle and chitosan.

The longest shelf life (15 days) was found in okra fruits preserved with plant leaf powder whereas minimum shelf life (7 days) was found in untreated fruits. This may be due to their capacity to reduce postharvest decay incidence. Liamngee *et al.,* (2018) reported that tomatoes coated with plant leaf powders got maximum shelf life (25 days) whereas minimum shelf life (21 days) was found in untreated fruits.

The results of this study has established that plant leaf powders of *Azadirachta indica* (Neem) and *Moringa oliefera* (Drumstick tree) possess antifungal potential and have the ability to increase the shelf life and maintain the physicochemical quality of okra fruits during storage. Among the okra varieties studied, clemson spineless gave better shelf life and physiological quality during storage. We therefore recommend the use of plant leaf powders particularly *Moringa oliefera* (Drumstick tree) for the storage of okra varieties.

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