Shelf Life Improvement of Okra: A Review

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ABSRACT

Okra is a vegetable crop belonging to family Malvaceae. Its botanical name is *Abelmoschus esculentus* (Linn.), the plant originated from West Africa. Food content of okra pods include minerals salts, vitamins and proteins and roughages.

Okra is a highly perishable commodity, after harvest of Okra, a great loss occurs because since the fruit undergoes continued respiration. Many post-harvest practices such as use of calcium chloride, modified atmosphere packaging (MAP), 1-methylcyclopropene (1-MCP), heat treatment, cold storage, use of plant extract, have been used to extend the shelf life okra and the use of plant extract is regarded as the cheapest, most practicable method but the extraction of compounds should be safe and eco-friendly.

Key Words: Okra, shelf life, postharvest methods, plant extract.

INTRODUCTION

Okra (*Abelmoschus esculentus L.*), plant is a warm season annual herb belonging to the family Malvaceae. The characteristics of the calyx, spathulate, with five short teeth, connate to the corolla and caducous after flowering (1). The plant has single yellowish colored flowers with a crimson center, characteristic malvaceous floral organization in the leaf axile on peduncles. The epicalyx has 8-10 very narrow, hairy, bracteoles. The leaves are large, lobed and leathery, alternately arranged with toothed margins, The immature fruits are oblong hairy capsules with light green or sometimes with red streaks when unripe but when ripe the fruits dry up and dehisce longitudinally realizing the seeds to the exterior (2).

The immature pods are used primarily for processing and the fresh market. Okra is very important fruit vegetable crop for human consumption (3). It is commonly grown vegetable crops in the tropics (3, 4). As food, okra can be eaten fresh or cooked and used as an additive in soups, salads, and stews (5). Okra is believed to have originated from Ethiopia. It has great economic importance in the subtropical regions of the world (6,7).

Okra is called ila in yoruba, okuru in igbo language, but it known as as lady's fingers, in many English-speaking countries (1), It is self-pollinated, propagated by seeds with a duration of 3 to 4 months (8). Okra can be grown on wide range of soils, but well drained fertile soils with adequate organic matter result to high yield. The crop is widely cultivated throughout the year in the tropics. (1). It is a non-climacteric vegetable when harvested and handled as an immature fruit (9).

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Okra is cultivated all over Nigeria basically in all states of the federation both as rain fed and irrigated crops (1,6). Overall, the trend in the cultivation of okra in Nigeria appears to be positive, with increasing numbers of farmers taking up the crop and utilizing modern agricultural practices to improve its productivity and profitability, in 2020 the yield of okra has increased to 1.82 million tons (11). Okra is now cultivated as an irrigated crop during the dry season, where it is often produced in mixed cropping with onion and other crops.

Okra is widely cultivated and consumed particularly in tropical of the world. In recent years, there has been a growing trend in okra cultivation as more people are becoming interested in growing their own food and looking for healthy and sustainable food options. In Africa, where okra is a staple food crop, there has been a growing demand for improved varieties of okra that are more resistant to pests and diseases. There is increased investment in agricultural research in a quest to develop new okra varieties with improved yields, longer shelf life, and better nutritional content (1). In Asia, okra is widely cultivated in Bangladesh, India, and Pakistan. In these countries, the trend has been towards using modern agricultural techniques to increase yields, reduce crop losses due to pests and diseases, and improve the quality of okra produced. In the United States, the interest in growing okra basically among home gardeners and small-scale farmers, particularly in the southern states (9). Resulting to the production of new okra varieties that are better suited to the local climate and soils and that produce high-quality crops with improved yields. Overall, the trend in okra cultivation worldwide is towards increased production and improved quality, driven by growing demand for healthy and sustainable food options and a desire for greater self-sufficiency in food production (9). Okra is a good source of protein, polysaccharides and minerals like Potassium, Iron, Zinc, Manganese, Nickel, Magnesium, Calcium, Iodine, etc., it is also rich in vitamins A, B and C. (3,4**).** Okra is also has high fibre content, and unsaturated fatty acids (6, 12). Okra contains about 4550 kCal/kg, making it a good source of calories for human consumption. Its fruit is tender, mucilaginous and flavorful, (9, 13)*;* It is also of value as roughage, a substance that helps in food digestion and prevents obstruction of the alimentary canal and other gastronomic disorders (14).

Okra is usually cooked in soups and stews in Africa, however it is eaten fresh in some countries. Okra fruit has a high moisture content. Okra mucilage can be used as food additives (7, 14, and 15) Okra seed contains unsaturated fats in quantities comparable to that of soybean oil, in actual fact the okra seed has the ability to reduce cholesterol levels in the body. Moreover, the seed oil also contains proteins that have essential amino acids just like many cereals except wheat (6).

According to (16), okra grown in kitchen gardening refugee camps in Ethiopia, Ugandan and Sudan were able to meet nutritional needs of children and women in the camps.

Okra gum has been used to increase fiber content of food product, it has helped in improving the consistency of unleavened bread made with rice flour. Okra extract has very strong adhesiveness and this property enables it to be can be used as a fat alternative in low-fat foods (9) the immature pods are also used in making pickle. Sugars from okra are used to sweeten ice-creams and chips, the mature fruits are used in the paper industry (13). Dried okra seed can be roasted and ground to be used as coffee substitute or ground to fortify flour of cereals thus helping in increasing the nutritional content of such flour (9).

Okra mucilage can also be used in as excipients in the production of drugs in the pharmaceutical industry, in the production of packing materials when mixed with corn starch, it can also be used as an aerating agent when mixing egg white powder, as an additive in the formulation of binding agent made of flour, as well as a constituent of for clarifying agent in the production of sugarcane juice. Okra mucilage in combination with acrylamide, can be used to produce paints and coating with biodegradable properties.

Furthermore, okra mucilage include brightening agents in electro deposition of metals, as a deflocculant in

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paper and fabric production, to remove suspended solids during water treatment and as a protectant to reduce friction in pipe-flow (6, 13).

Medically, Okra mucilage can now be used as a plasma replacement or blood volume expender (6). It is also used in some parts of the world in the treatment of gastric inflammations and irritations (14).

The purpose of this review, is to outline some postharvest treatment methods commonly used by farmers globally and identify the best method that can be easily utillised by local farmers and market women in sub-Saharan communities like Nigeria to effectively extend the shelf life of okra.

SHELF LIFE OF FRUITS

Shelf-life is a period for which a fruit or vegetable retains an acceptable quality from a safety or organoleptic point of view (17). The fruit becomes unfit for consumption after shelf life. This process of ageing of fruits after harvest refers to fruit's shelf life. Fruits are living even after harvest, they also have high water content (3). Fruits usually have food and water stored in them. The rate at which these food and water content reduce determine the shelf life of these fruits. As soon as the food and water reserves are depleted, the fruit stops living becomes dead and putrefies. Substances or processes makes fruits to lose food and water reserves ultimately leads reduce shell life of fruits (18). Shelf-life of fresh okra is usually two to three days (19),

2.1 Environmental Factors Affecting Shelf life of fruits.

Factors affecting shelf life of fruits include;

Temperature

Temperature is a very important factor that affect shelf life of fruits after harvest. Therefore, cooling and refrigeration are important in preserving the quality of fresh fruits and vegetables and to extend their storage lives. If the temperature the fruit is exposed is too low the fruit suffers chilling injury, alternately if the temperature is too high, the fruit undergoes accelerated respiration and transpiration leading to increased water loss thereby reducing the storage life of the fruit (3, 9). Okra can keep well at 7-10 ºC for two weeks (3, 20).

Relative Humidity

This is the amount of water vapour present in air expressed as a percentage of the amount needed for saturation at the same temperature. Too humid conditions leads to the growth of molds on the fruit thereby leading to decay, on the other hand, low relative humidity will lead to increase in loss of water content in the fruits leading to fruit shrinkage and subsequent unappealing appearance (21).

Relative humidity value for storage of fresh fruits depends on the fruit. For okra, the recommended humidity level is 90 to 95% (20).

Atmospheric Composition

This refers to the normal chemicals present in the atmosphere of the earth. The main gases are nitrogen and oxygen, there are others in trace amount, and one of such is Carbon dioxide. It follows that if oxygen level is reduced and the carbon dioxide level is increased, the rate of fruit decay can be drastically reduced. However if the carbon dioxide is too high, it can lead to fruit deterioration with symptoms like softening and change in fruit colouration (22) reduction in oxygen level reduces the rate of respiration, thus helping in

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extending the fruit shelf life (23). The recommended levels for pepper is 3% Oxygen in combination with 5% carbon dioxide at 5 to 10ºC. This condition can keep the fruit for three to four weeks (20).

Physicochemical Quality of fruits

Weight loss percentage; this is the percentage weight lost by an organism over a specific period. It tends to increase as temperature and period of storage increase (22). Fruit weight loss is caused by depletion of food and water reserves of fruits after harvest (24).

Weight loss of fruits impacts greatly on physical appearance of the fruits. The fruit may shrink or soften making it unappealing to consumers (9).

Fruit firmness

This is a measure of compactness of a fruit when pressed, the fruit is supposed to give a sound when broken. Fruit firmness is affected by type of fruit, rate of ripeness, fruit handling during harvesting, and presence of calcium in the fruit (9, 22). Fruit firmness decreases as turgor pressure decreases in the fruit wall, the fruit become flabby and soft, losing its appeal and attractiveness to consumer (9, 24). Firmness is also dependent on the thickness of fruit wall and presence of wax on the outer fruit surface since the wax helps the fruit to retain water thus helping the fruit to retain its crispiness (22).

Fruit decay

Fruit decay or rot is the process whereby flesh of fruits is destroyed and the seeds are exposed, it occurs naturally in fruits or it may be caused by microorganisms. Fruit decay can be affected by temperature, amount of water available, light, presence/absence of oxygen. However rate of fruit decay depends on fruit type (25), Of the many microorganisms responsible for fruit decay, fungi are the major group, apart from these some fungal species produce mycotoxins which are hazardous to health (26).

2.4. Chemical Quality Properties of fruits

After harvest, the food reserve in a fruit to undergo metabolism leading to accumulation of sugars. These sugars affect the taste of the fruit however the sugar produced differ from fruit to fruit (9).

Total soluble solids (TSS), This is accumulated sugars value which is expressed as as percentage of mass of the fresh matter it is a reflection of type of sugars present in fruit after harvest.

Titratable acidity (TA) used to express the amount of free predominant acid in a fruit and TSS/TA ratio of fresh fruit is used to determine the taste and feel of fruit (24). The values of TSS, TA and (TSS/TA) vary as the fruit develops and age after harvest (22, 23 and 27). It is evident that if the rate of respiration is reduced, the rate of production and metabolism of these sugars will reduce hence the fruit will have lower TSS (23).

Fruit pH: Indicates the degree of concentration hydrogen ions in a fruit it is the measure of acidity or alkalinity of a fruit. Most fruits have PH value ranging from 3-5. PH is affected types of fruit, soil used for planting, level of development at the time of harvest. Acids present in fruits help to maintain acid base balance in the body foods. The acid is also responsible for the taste and flavor fruits. Most fruits contain citric acid (28*)*. As the fruit age in storage, the pH increases due to loss of citric acid (22).

2.5 Pre and postharvest losses of Okra: Many forces come to play when considering pre and postharvest losses of Okra such forces include weather conditions, farming methods, fruit type, soil type, harvest methods, etc (9,20). The morphological characteristics of Okra can also be a great influence on the loss of the fruits. The fruits have thin cell walls, and they are easily injured and bruised, moreover, carbon dioxide,

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oxygen and water vapour are able to move in and out of the fruits much more easily than fruits with thicker walls because of the presence of stomata and the nature of calyx and stem area (29).

Post-harvest diseases of Okra.

Post-harvest losses in Okra are caused by incidence of Fungal and Bacterial diseases such as *Fusarium* wilt, *Rhizoctonia* rot, *Phytophtora* blight, bacterial decays etc. (30). These diseases attack the fruits after harvest and they are responsible for over fifty percent loss of fruit yield. Losses may also be due to mechanical injury and desiccations (9, 24).

Furthermore, ethylene exposure causes fruit decay especially during marketing, leading to the softening and reduction in storage life of the fruit (29).

Post-harvest Treatments of Okra

Cold storage

This includes facilities that store food products like fruits, vegetables, fish, meat etc. that have specific temperature requirements to avoid decay or contamination. Storing Okra at 8 ± 1^0 C in polypropylene packs was able to keep Okra for twelve days with the colour and other sensory qualities of the fruit well sustained, even though the normal shelf life of Okra at room temperature is 3days (3, 17).

Use of 1-Methylcyclopropene(1MCP): Studies have shown that Methylcyclopropene can prevent the chilling injury symptoms of some fruits, such as apple, pineapple, etc (31). 1MCP is a cyclopropene derivative it is used as synthetic plant growth inhibitor. It is used to inhibit ethylene production in stored fruits it works by binding to the ethylene receptors thus interfering with ethylene binding and functioning. It has been found that treating unripe fruits with MCP can delay ripening for weeks (31). Using 1-Methylcyclopropene on okra helped to decrease its browning the fruit by inhibiting lipid peroxidation and maintaining membrane integrity, probably due to increased antioxidant or free radical radical-scavenging action, MCP also helped in sustaining fruit firmness and viscosity of the Okra mucilage (9, 22).

Heat treatment

This is a method to care for texture of fruit quality during storage. Heat treatments include exposure to hot air, hot water dips or vapour dips (33). The treatment was initially intended to combat pest and diseases of crops (34). The rate of respiration has direct correlation with temperature (35). Increase in temperature can also lead to proliferation of spoilage organisms (9). Studies have revealed additional benefits of heat treatment on stored fruits included fruit preservation while maintaining its nutrient content and eliminating chilling injury (36). When Okra was subjected to heat treatment of 40°C for half an hour and afterwards stored them at 10°C, no chilling injury was detected and the shelf life was extended (37). Also dipping okra pods in hot water for 1 minute at 50°C, then storing at room temperature (15-20°C) indicated no chilling harm and the pod weight loss, electrolyte leakage, off odor, decay, and visual appearance were all minimized (9) and the treatment extended the shelf life by 21 days. Studies have revealed, that heat treatment helps in down regulating redox metabolism proteins and up regulating chilling injury resistant associated proteins (38).

Use of Modified Atmosphere Packaging (MAP) Gas concentrations

This is a process whereby the gaseous component in a packing material in which fruits are kept are varied in a bid to preserve the fruits that are packed in them for a longer period (39). Results have revealed that when Modified Atmosphere Packaging was employed in storage of Okra the fruit retained its firmness, also the

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bright green colour as well as the viscous quality of its mucilage was sustained (9).

The Modified Atmosphere Packaging also helped in lessening loss in the weight of the fruit regardless of the storage temperatures aside this, use of MAP also helped in retaining antioxidants in the fruit (40).

Also use of MAP has helped in reducing chilling injury in okra by reducing the rate of respiration and production ethylene thus increasing the overall acceptability of the fruits (40).

However, one should be careful so that anaerobic microorganisms do not develop in the packs (41). Moreover some nations view using these plastic packs as a way of accumulating environmental wastes thus making the use of MAP in such countries impracticable.

Application of Calcium Chloride

Dipping fruits in calcium solution helped to add more calcium molecules to the fruit, this will help in delaying the rate of decay of these fruits, and the soluble sugar content of such fruits is retained, also customer acceptability of such fruits is not affected (19). Calcium prevents chilling injury since it is an essential nutrient for building up cell wall and cell membranes of plants. It is also important as a cation in the vacuole and as intracellular messenger in the cytosol (42).

The effect of Calcium Chloride treatment on fruits include, suppression cell death, reduction of chilling injury, reduced susceptibility to pests and diseases and inhibition of physiological disorders stored the fruits (43).

When fresh okra fruits were treated with five percent solution of calcium chloride and kept in plastic packs at low temperature, The weight loss, microbial load, and blackening of the fruits were reduced, the shelf life also increased from 3-8 days (44).

Use of plastic films

Results indicate that using plastic films to store fruits can help to improve the shelf life of fruits (3). When okra was stored in plastic bags with 30 µ m thickness, the rate of water loss and colour loss reduced drastically and the fruit maintained its sensory qualities even after 21 days storage at low temperature (20). It is worthy to note that plastic films tend to add barriers to the fruits thus reducing to fruit moisture loss.

Storage in evaporative cooler (EC)

An evaporative cooler is a device that cools air through the evaporation of water. Evaporative cooling has been found to be the cheapest and effective way of cooling storage structure in comparison with commercial cold storage (45). However effect on storage varies with fruits. When Habanero pepper fruits are stored in an evaporative cooler (EC),the fruits had lower rate of weight loss ranging between 9.65% and 28. 86% depending on the varieties, the fruits also maintained acceptable sensory qualities, there were no shrinking and color change (46). One disadvantage of the evaporative cooler is that it can facilitate fruit decay so one must find ways of controlling its moisture content (45). Storing Okra in evaporative coolers have helped to improve the shelf life of both fruits by 10 days, depending on the variety, as compared to when stored at ambient temperature (3,46).

Edible coating

This is when a thin layer of harmless ingestible substances which are environmentally friendly are rubbed on outer surface of fresh fruits and vegetables. The coating helps to augment the normal functioning of the

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wax on the cuticle of the fruits, such as protection against wounding and invasion of microorganisms. It also helps to control moisture loss, exchange of gases within the walls of the fruits. The effects of this coating include retention of antioxidants, retention of favourable sensory qualities, etc. in fruits (9, 46, and 47). Common coatings include beeswax, maize starch, cactus mucilage, etc. (47, 49). The shelf life of okra fruits has been extended to 14day when coated with chitosan /cellulose composite(7).

Use of plant extracts to improve shelf life of okra.

Recently plant extracts are incorporated into edible coatings used in preserving fruits, the result obtained indicated that the presence of the plant extract helped in reducing the rate of fruit decay and weight loss in stored fruits ,thus helping to improve the shelf life of the fruits even at room temperature(47).

Plants are cheap, easy to use and can be utilized to extend the shelf life of food. Traditionally, many plants parts, have been used to treat many ailments in humans (50). Plants contain several phytochemicals with antimicrobial and antioxidant properties (51). Plant extracts are now being used to preserve food due to their polyphenols and carotenoids (52). Phenolic compounds are particularly antagonistic to harmful microorganisms, they also exhibit antioxidative properties (53). Leaf extract of Neem plant have been found to have antimicrobial activity against microbes responsible for spoilage of tomatoes (54). Also, extracts of bay leaf and green tea extracts helped in the preservation of salted fish with vacuum packaging (55). Same effect with preservation of comminuted meat with plant extract(52). They also delay the development of off-flavors and improve the shelf life and color stability of food products. Extract of *Anona. muricata* have been used to preserve tomato fruit (65). Likewise Ogbaji and Iorliam(71) used extracts of *Azadirachta indica* and *Moringa oleifera* to preserve okra for 15 days.However there is need for evaluation on toxicological studies on foods preserved with extracts of plants. Safety of such foods has to be established before the extract of *A. muricata* can be accepted as a food preservative.

CONCLUSION

Shelf life extension of okra with plant extracts have been found to be effective and cheap. The efficacy may have to be reflected in vivo studies. The method extraction from the plants should be cost and eco-friendly so to ensure the stability of the plant extracts under varying conditions

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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