

# Okra preservation: Processing techniques, nutritional value, and health impacts

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## **Abstract**

This review explores the nutritional profile, health benefits, and preservation techniques of okra (*Abelmoschus esculentus L. Moench*), emphasizing its contribution to achieving the United Nations Sustainable Development Goals by reducing food waste. Fresh okra is a nutrient-dense vegetable rich in dietary fiber, essential vitamins (A, C, and K), and minerals, offering significant health benefits such as cholesterol management and kidney disease prevention. However, its high moisture content leads to rapid post-harvest spoilage. Comparative analysis reveals that while dehydration techniques like sun-drying extend shelf life and reduce anti-nutritional factors, it may result in the loss of beta-carotene and retinol. Various processing methods, including canning, freezing, and roasting, further influence its nutritional density and culinary versatility. The study emphasizes the need for controlled drying environments and advanced technologies to optimize okra's potential as a sustainable, year-round food resource.

**Keywords:** Okra preservation, food waste reduction, nutritional composition, drying techniques, sustainable food systems

## Okra preservation: Processing techniques, nutritional value, and health impacts

### 1. Introduction

In alignment with the United Nations Sustainable Development Goals, specifically the aim to “halve per capita global food waste at the retail and consumer level, and reduce food losses along production and supply chains by 2030,” it is imperative for institutions to approach this issue with utmost seriousness and commitment. Global food waste is a persistent issue that begins in agricultural production and continues through every stage until it is disposed of in landfills. According to Safdie (2023), more than 30% of the world's food is lost or wasted each year, a figure that is especially significant given the global prevalence of food shortages. This necessitates the development of comprehensive ways to handle this complex challenge. Martindale and Schiebel (2017) addressed the pressing issue of food waste in their study. Their research indicated how consumer food waste behaviors play a critical role in a variety of sustainability challenges related to meal preparation decisions, emphasizing the connection between food preservation and reduced consumer waste.

According to Torres-Leon and Aguilar (2022), preventing food spoilage from bacteria involves keeping the food germ-free (asepsis), getting rid of existing germs through filtration, creating conditions that hinder microbial growth (like low temperatures, dehydration, anaerobic environments, and chemical preservatives), and destroying microorganisms. Food preservation, which dates to prehistoric times, encompasses strategies that prevent deterioration and lengthen the shelf life of produced food. The major goal is to keep bacteria populations under control. This strategy is critical for guaranteeing seasonal food availability, improving overall accessibility, and utilizing resources in areas of excess production. Drying is an ancient cornerstone of food preservation, with historical traditions harnessing the sun, wind, and smoke from fires to dehydrate fruits, meats, cereals, and plants (Ahmed et al., 2013). However, due to its broad applicability and occasional lack of precision, this process may not always eliminate moisture, resulting in a finished product with a slight residual moisture content (Hasini, 2023).

With the progression of time, advancements in technology have given rise to new preservation methods. The methods include canning, pasteurization, freezing, irradiation, and adding chemicals (Singh & Desrosier, 2023). Fruits and vegetables are typically subjected to the preservation process. They tend to deteriorate quickly after being harvested because of their high moisture content, leading to a decline in qualities like fragrance, color, appearance, and nutritional value. In the Philippines, where there is an abundance of fruits and vegetables, the process of preserving these crops is vital. This is to prevent wastage and extend the freshness of the produce. Okra is a staple in Filipino households and a key ingredient in native cuisine (Tacio, 2021). In recent years, there has been a rise in okra innovation and development, with 2021 representing an important milestone as the country expands its exports internationally (Portcalls Asia, 2021). With the escalating popularity and demand for okra, a thorough analysis and review of its nutritional composition, health advantages, and processing methods can provide valuable insights for maintaining freshness and improving nutritional value. This may hold the potential to contribute to the realization of sustainable development goals in global food preservation, guiding stakeholders toward a methodical and conscientious approach to supporting community sustenance and responsibly preserving global resources.

### 2. History of Okra

Okra, scientifically known as *Abelmoschus esculentus L. Moench*, is an annual vegetable crop. It is a highly recognized and extensively used plant belonging to the Malvaceae family (Naveed et al., 2009). It typically grows to 3 to 6 feet (Pendre et al., 2012; Afolabi & Agarry, 2014). It is a valuable vegetable crop cultivated in tropical and sub-tropical regions worldwide, holding significant economic importance (Oyelade et al., 2003; Andras et al., 2005; Saifullah & Rabbani, 2009). In its origin in Ethiopia, it is also called Kenkase (Berta), Andeha (Gumuz), Bamia (Oromica/Amharic). Okra probably derives from one of Niger-Congo groups of languages (the name for

okra in the Twi language is nkuruma (Benjawan et al., 2007). The term okra was used in English in the late 18th century (Arapitsas, 2008). Okra has a rich culinary history, appearing in Middle Eastern and Mediterranean cuisines since the 12th century due to ancient trade routes. In West Africa, it plays a crucial role in various soups and stews, lending a distinct thickness. Known as “bhindi” in India, okra is a key ingredient in stir-fries and curries. Egypt, Greece, and Turkey each have their own take on okra dishes, often using local flavors and simmering them in tomato sauces. Some places still follow the traditional method of pickling okra. Okra is adapting to modern cooking styles globally, featuring in contemporary dishes like salads and innovative grilling methods, preserving its unique flavor and contributing to modern gastronomy (Sophiax, 2023).

**Nutritional Composition of Okra** - Okra, often referred to as a “perfect villager's vegetable,” possesses a distinctive nutritional profile, making it a valuable addition to diets. Several studies have shed light on its nutritional components, highlighting its rich content of dietary fiber, well-balanced amino acids in seed protein, and the notable linoleic acid abundance in its seed oil (Holser & Bost, 2004; Sanjeet et al., 2010; Andras et al., 2005).

**Protein and Essential Fatty Acids** - The protein content in okra seeds, similar to soybean, exhibits a higher Protein Efficiency Ratio (PER) than soybean, rendering it an excellent complement for legume or grain-based diets (Adetuyi et al., 2012). The oil extracted from okra seeds, constituting a substantial portion of linoleic acid, serves as a valuable source of essential polyunsaturated fatty acids crucial for human nutrition (Savello et al., 1980).

**Carbohydrates, Vitamins, and Minerals** - In addition to proteins and essential fatty acids, okra is rich in carbohydrates, vitamins, and minerals (Owolarafe & Shotonde, 2004; Gopalan et al., 2007; Arapitsas, 2008; Dilruba et al., 2009). The nutritional composition of okra pods per 100 g of edible portion reflects a balance of various essential nutrients, including water, energy, proteins, carbohydrates, fats, fibers, calcium, phosphorus, iron,  $\beta$ -carotene, riboflavin, thiamin, niacin, and ascorbic acid.

**Dehydrating Techniques and Nutritional Changes** - Studies by Shaibu et al. (2023), Avallone et al. (2008), and Musa (2008) illustrate the impact of dehydrating techniques on the nutritional composition of okra. The statistical analysis of Shaibu et al. (2023) highlights significant variations between fresh and dried okra, emphasizing the need for controlled drying environments to prevent contamination. Avallone et al. (2008) report that dried okra sauce lacks beta-carotene and retinol. Musa's (2008) research suggests that traditional sun drying can reduce anti-nutritional factors and enhance protein and mineral availability. In essence, the nutritional significance of okra extends beyond its robust fiber content. Studies previously mentioned collectively reveals the need for meticulous consideration of processing methods to optimize its nutritional profile, emphasizing the potential of dehydration techniques in enhancing the overall nutritional density of okra.

### 3. Comparative Analysis of Nutritional Components in Fresh and Dried Okra

**Proximate Analysis Disparities** - The statistical analysis in the study of Shaibu et al. (2023) reveals noteworthy disparities in the proximate analysis between fresh and dried okra. While the mineral composition remains consistent across both forms, the sun-drying process creates a substantial reduction in anti-nutritional content, although alkaloid and flavonoid levels remain relatively high. It stresses the importance of creating controlled drying environments to mitigate potential microorganism contamination and adhere to international food processing standards.

**Absence of Beta-Carotene and Retinol in Dried Okra Sauce** - Building on these findings, the study of Avallone et al. (2008) support the outcomes by highlighting that dried okra sauce, a prevalent West African culinary item composed of okra pods and additional ingredients, lacks beta-carotene (vitamin A) and retinol. This observation shows the need for several considerations when relying on dried okra preparations for specific nutritional requirements.

**Nutritional Composition Changes under Traditional Sun Drying** - Musa's (2008) study on the traditional

sun drying methods provides optimistic insights. The study identifies a reduction in anti-nutritional factors like phytic acid, tannin, and polyphenols. Importantly, this reduction aligns with an enhanced availability of proteins and minerals, as demonstrated by *in vitro* protein digestibility and mineral assessments. These results suggest that the traditional sun drying of okra has the potential to enhance its overall nutritive value. Moreover, Al-Dabbas et al. (2023) conducted a comprehensive investigation into the overarching effects of diverse processing and preservation methodologies on okra. The focus of their study revolves around the evaluation of total phenolic and flavonoid contents, coupled with an assessment of antioxidant activities. The findings reveal subtle yet significant variations in samples preserved using identical methods during storage. Interestingly, the study identifies blanching and freezing as protective measures, ensuring the highest preservation of phenolic contents and antioxidant activities in okra.

The insights from the studies of Shaibu et al. (2023), Avallone et al. (2008), and Musa (2008) shows the significant impact of dehydration techniques on the nutritional composition of okra. The studies reveal substantial differences in anti-nutritional content and mineral components between fresh and dried okra. Shaibu et al. (2023) stress the imperative need for stringent environmental controls during drying to prevent contamination. While Avallone et al. (2008) point out specific deficiencies in beta-carotene and retinol in dried okra sauce, Musa's (2008) findings propose that traditional sunlight drying might contribute to an improved nutritional profile, aligning with the objectives of food science and nutrition researchers and practitioners in optimizing okra's nutritional density.

#### 4. Health Benefits of Okra

Okra stands out as a nutritional powerhouse, offering a numerous health benefits attributed to its rich vitamin and mineral content, supporting overall well-being.

***Cholesterol Management and Weight Loss*** - According to Zaharuddin et al. (2014), okra plays a significant role in managing cholesterol levels and promoting weight loss, making it a valuable component in a healthy, low-cholesterol diet.

***Essential Vitamins for Vision, Skin, and Bone Health*** - Packed with essential vitamins A, C, and K, okra contributes to various aspects of health, including vision, skin health, and bone mineralization. The high folate content is particularly beneficial for pregnant women, aiding in neural tube formation during early pregnancy (Zaharuddin et al., 2014).

***Antioxidant Richness and Potential Chemo-preventive Properties*** - Okra serves as a powerhouse of antioxidants, including quercetin and catechin, effectively combating oxidative stress. These antioxidants may have anti-fatigue effects and suggest potential chemo-preventive properties and a reduction in brain inflammation, although further research is needed for conclusive evidence (Messing et al., 2014).

***Hydration, Electrolyte Balance, and Antiadhesive Properties*** - The high-water content in okra contributes to hydration and provides essential electrolytes like potassium, regulating blood pressure and supporting muscle function. Furthermore, the polysaccharides in okra exhibit antiadhesive properties, helping prevent the spread of harmful bacteria in the stomach (Messing et al., 2014).

***Kidney Disease Prevention and Palatability Enhancement*** - The study of Lengsfeld et al. (2004) suggest that regular consumption of okra may contribute to kidney disease prevention, particularly for individuals following a diabetic diet. Despite its slimy texture, cooking methods like roasting, grilling, or frying can enhance palatability, encouraging incorporation into a balanced diet with other vegetables. Emphasizing the importance of choosing natural over processed options, Messing et al. (2014) also emphasized the holistic benefits of including okra in a well-rounded and health-conscious diet.

#### 5. Processing Techniques of Okra

***Cultivation and Harvest Practices*** - Farinde et al. (2007) illuminate the initial stages of okra cultivation,

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emphasizing meticulous land preparation techniques—clearing, ploughing, harrowing, and heaping or ridging. The study delves into the diverse plowing implements employed by farmers and reveals a rhythmic harvest frequency, occurring once every five days. Significantly, the study features the prevalence of manual and semi-modern processing methods for both fresh and dried okra. Ngbede et al. (2014) studied okra processing techniques in Nigeria's landscape, validating and enriching processing findings. Tools wielded in processing, such as knives, graters, mortar and pestle, and grinding stones, were identified. They highlighted preservation techniques in their research, illustrating process of preserving fresh okra in baskets for a limited duration, while sliced okra undergoes three days of sun drying before storage in various containers for future use.

**Culinary Techniques** - Asamani and Maalekuu (2023) also contribute significant insights to the discourse on okra processing. They identify prevalent culinary techniques such as slicing, pounding/milling, and roasting. The nutritional analyses conducted in the study area unveil variations in the composition of sliced and roasted okra fruits. Sliced okra exhibits higher levels of fiber, ash, and calcium, whereas roasted counterparts boast increased carbohydrate richness. This study sheds light on how diverse culinary methods influence the nutritional profile of okra.

**Drying Methods** - Tsado (2015) explores the complexities of drying procedures for okra, providing insights into three distinct approaches. The highest level of exceptional dryness is attributed to sliced okra fruits that are dried directly under the sun, followed closely by the method of sun-drying in close proximity. Despite being less popular, oven drying enhances the understanding of the wide variety of drying methods available for okra.

**Other Preservation Techniques** - Christian (2015) enhances the complexity of okra preservation by incorporating sophisticated methods such as canning, pickling, freezing, and drying. The study requires the use of pressure-canning to ensure safety, taking into account the low acidity of okra. Okra that is not combined with other ingredients can be preserved by using a pressure canner. However, if the okra is pickled or treated with acid, it can be safely preserved using a boiling water canner. Cryogenic processes undergo a refined transformation, as more streamlined variations elevate the overall excellence. Drying okra can be easily accomplished using either a food dehydrator or an oven sets to a temperature of 140°F. The given instructions minimize the necessity of blanching, providing a straightforward yet effective method of preservation.

**Comparison of Fresh and Dried Okra**

Aspect	Fresh Okra	Dried Okra
Nutritional Composition	Rich source of dietary fiber	Maintains significant fiber content
	Balanced amino acids; high Protein Efficiency Ratio (PER) Abundant linoleic acid in seed oil Rich in carbohydrates, vitamins, and minerals High water content Contains anti-nutritional factors Presence of beta-carotene and retinol  Balanced nutritional profile	Retains amino acids, although slightly reduced  Concentration of linoleic acid is maintained Rich in carbohydrates; preserves vitamins and minerals Reduced water content; retains nutrient density Reduced anti-nutritional factors through drying Beta-carotene and retinol largely absent, especially in dried sauces  Concentrated nutrients, with some losses
Health Benefits	Supports cholesterol management Essential vitamins for vision, skin, and bone health Antioxidant richness and potential chemo-preventive properties Hydration, electrolyte balance, and antiadhesive properties Contributes to kidney disease prevention Enhances palatability through various cooking methods	Retains benefits for managing cholesterol Preserves essential vitamins, with some losses Maintains antioxidant properties; some losses observed  Retains hydration benefits; antiadhesive properties maintained Preserves benefits for kidney disease prevention Culinary versatility maintained
	Processing Techniques	Limited to fresh consumption Prone to spoilage and shorter shelf life Blanching unnecessary for fresh consumption  Suitable for immediate culinary use

Fresh okra is a rich source of dietary fiber, boasting a balanced amino acid profile with a high Protein Efficiency Ratio (PER) and containing an abundant amount of linoleic acid in its seed oil. Additionally, it is rich in carbohydrates, vitamins, and minerals, with a high-water content. However, it contains anti-nutritional factors, which are reduced through drying. Fresh okra also presents the presence of beta-carotene and retinol, contributing to its balanced nutritional profile. In comparison, dried okra maintains a significant fiber content, although there is a slight reduction in amino acids. The concentration of linoleic acid is sustained, preserving its nutritional value. Dried okra remains rich in carbohydrates, preserving vitamins and minerals, with a reduced water content to retain nutrient density. The drying process effectively reduces anti-nutritional factors, although beta-carotene and retinol are largely absent, particularly in dried sauces. Despite some nutrient losses, dried okra still offers a concentrated nutrient profile.

In terms of health benefits, both fresh and dried okra support cholesterol management and retain essential vitamins, albeit with some losses in the drying process. They maintain antioxidant properties, with dried okra observing some losses. Both forms contribute to hydration, electrolyte balance, and possess antiadhesive properties. Additionally, they contribute to kidney disease prevention, with dried okra preserving these benefits. The palatability of okra is enhanced through various cooking methods, with culinary versatility maintained in both fresh and dried forms. When it comes to processing techniques, fresh okra is primarily limited to immediate consumption, making it prone to spoilage and having a shorter shelf life. In contrast, dried okra undergoes diverse preservation methods such as canning, pickling, freezing, and drying, extending its shelf life. While blanching is unnecessary for fresh okra, dried okra requires specific techniques like canning, pickling, and freezing for preservation. Dried okra offers convenience and flexibility in usage, allowing for varied culinary applications.

## 6. Conclusions

This article reviews on the nutritional composition, health benefits, and processing techniques for okra represents a significant advancement in tackling the urgent global problem of food waste. This research is in line with the United Nations Sustainable Development Goals, which seek to reduce global food waste by 50% per person by 2030. The study offers practical insights for various community members to actively participate in sustainable practices, reduce food waste, and properly manage global resources by highlighting effective preservation methods, specifically drying okra. To summarize, okra is not only a widely used ingredient in cooking with a significant historical background, but also a versatile resource that plays a vital role in world food security. This article examines how different processing processes affect the nutritious components of food, emphasizing the importance of deliberate approaches to food preservation. Furthermore, this study promotes an intensive and thoughtful approach among stakeholders to utilize the potential of okra in enhancing a food system that is both sustainable and resilient.

**Recommendations** - To conduct a comprehensive investigation on dried okra, it is recommended to broaden the scope of the nutritional analysis to encompass a meticulous assessment of micronutrients, antioxidants, and bioactive compounds. It is important to consider factors such as cultivation techniques and regional origins. In addition, carrying out a long-term study on the health advantages of routinely consuming dehydrated okra will provide substantial insights into its enduring effects. This study entails partnering with healthcare professionals to assess specific health indicators longitudinally. Broadening the range of research on health benefits to include aspects such as anti-inflammatory properties, digestive well-being, and immune system reinforcement would yield a more thorough understanding. It is imperative to incorporate a qualitative element to evaluate consumer attitudes and behaviors towards dried okra, encompassing preferences, challenges, and potential barriers. It is crucial to give priority to enhancing processing operations, specifically by evaluating cutting-edge drying technologies and collaborating with food engineers to enhance efficiency, cost-effectiveness, and scalability. It is necessary to consider sustainability and environmental impact when it comes to growing and processing procedures.

In order to enhance the acceptance and utilization of dehydrated okra, it is imperative to conduct a comprehensive analysis of its gastronomic applications, create appealing recipes, and collaborate with agricultural

communities to acquire knowledge about conventional drying techniques. To expand the global knowledge base, it is crucial to prioritize consumers and professionals while developing community outreach and education activities. Furthermore, it is significant to disseminate research findings by means of publishing in scientific journals and delivering presentations at conferences. These recommendations improve the understanding of dried okra while offering significant insights for public health and sustainable agricultural practices.

**Implications** - The findings of this review carry important implications for education, particularly in strengthening the integration of food preservation, nutrition, and sustainability concepts into school and community-based curricula. Since the paper highlights okra as a nutrient-dense crop with strong potential for reducing food waste through preservation techniques, educators and curriculum developers may use this topic as a practical example in teaching sustainable development, food security, and health education. Integrating lessons on crop utilization, post-harvest handling, and simple preservation methods can help learners connect scientific knowledge with everyday life, while also supporting awareness of the United Nations Sustainable Development Goals related to responsible consumption and reduced food loss.

For *teachers*, the review suggests the value of using locally available agricultural products such as okra as instructional material in science, livelihood education, technical-vocational courses, and even interdisciplinary sustainability projects. Teachers can transform the topic into experiential learning activities by asking students to compare fresh and dried food products, examine nutritional changes during processing, or demonstrate traditional and modern preservation techniques. In this way, instruction becomes more contextualized, practical, and community-oriented. The topic also encourages teachers to emphasize evidence-based decision making, especially when discussing how certain preservation methods may extend shelf life while also affecting selected nutrients.

For *learners*, the study highlights opportunities to develop both knowledge and life skills that are relevant to health, household food management, and environmental responsibility. Through learning about okra preservation, students may better appreciate the relationship between nutrition, food preparation, and waste reduction, while also gaining skills that can be applied in daily living or future livelihood activities. This can foster more responsible attitudes toward food consumption, promote healthier dietary choices, and encourage students to value indigenous and locally accessible resources. More broadly, the topic helps learners see that preserving food is not only a household practice but also a meaningful contribution to community resilience and long-term sustainability.

**Declaration of Use of Artificial Intelligence** - Artificial intelligence (AI) tools were used in a limited capacity to assist with language editing, grammar correction, and improvement of sentence clarity in this manuscript. These tools were not used for data collection, data analysis, interpretation of results, or the development of the study's core arguments and conclusions. The author takes full responsibility for the accuracy, integrity, and originality of the final manuscript.

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