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Post-Harvest Processing of Okra (Abelmoschus esculentus L.): A Comparative Review of Drying, Freezing, and Emerging Fermentation Approaches on Phytochemical Stability and Bioactivity

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ABSTRACT

Okra (Abelmoschus esculentus L.) is a valuable vegetable that is nutritious and moisture-rich, and its post-harvest weakening occurs rapidly. The choice of intervention method is crucial for the retention of its value-added phytochemicals and functional properties. This review presents contemporaneous data on the preservation of okra using aeriation, freezing, and various thermal pre-treatments and new frontiers of fermentation. A systematic search of the literature on studies from 2014 to the early 2026, was carried out on all the major search engines of the scientific literature, and the selected papers were compared on the basis of the methods of preparation of the sample, the methods of analysis, and the changes in their bioactive compounds. Freeze-drying was superior to retain bioactive compounds, phenolics, and flavonoids, in addition to vitamin C and chlorophyll but is expensive and energy-intensive. Various forms of Microwave Vacuum Drying, Heat-Pump Drying, and other Assisted Drying methods provided the best trade-off between the quality of the final product and cost/energy efficiency, while conventional hot-air drying resulted in high loss of heat-labile compounds. During storage, the quality of frozen samples was better than that of air-dried samples, especially when barriers of the cold chain were implemented to minimize oxidative deterioration. Light exposure bettered enzyme deactivation, but leaching could occur, diminishing water-soluble phytochemicals, with its effect relying on the drying method employed. Contrary to previous assertions suggesting no evidence of fermentation in the okra preservation literature, evidence is now emerging that spontaneous fermentation of seeds and lactic fermentation of okra juice and polysaccharide systems is a substrate-dependent method of preservation and may enhance the extraction and activity of phenolics and antioxidants, and may also alter the viscosity and defensively improve the immunity of the polysaccharides. At present, steam blanching, then freeze-drying, is the best way to create nutrient-dense, dried okra. Of the methods to store dried okra, freezing is the best option if cold-chain resources are available. More studies should set standardized measures for fermentation parameters, sensory analysis, shelf-life tests, and tech-economic analysis for better adapted industrial use.

1-Introduction

Okra (Abelmoschus esculentus L.) is an important vegetable and now combined with many foods containing phenols, flavonoids, vitamins, carotenoids, and mucilaginous polysaccharides, are now classified as functional foods [1–3]. Phenolic profiling published reports contain quercetin glycosides including rutin, isoquercitrin, protocatechuic acid, and quercetin-3-O-gentiobioside, which are linked with antioxidant activities and inhibition of enzymes [2,3]. Despite their great nutritional value, quercetin glycosides are known to be highly perishable, okra fruits are thought to contain about 88 – 90% moisture of their total weight [4–6].

Ventilation helps sustain the quality of okra over time, it also enables the octra to be formed into a powder, flakes, and other ingredients. The type of drying used will also impact the efficiency of the process and the quality of the resulting product. Hot-air drying is usually the cheaper and easier to use method, however, it does often result in the faster loss of the okra's pigments and leads to the discoloration, shrinkage, and loss of the phytochemistry of okra [5,6,9]. On the other side, low temperature and other drying methods that are highly efficient, like freeze drying and (heat pump drying), Vacuum drying, and (Microwave-Vacuum drying), will produce better quality okra, but will be more expensive to produce.

Another useful method is freezing since it doesn't remove the water while still inhibiting the reactions and enzymes; thus, it is very important for retail and food service supply chain logistics [10,11]. Also, steam blanching or hot water blanching as a pre-processing technique might help as well in product stability by inactivating the enzymes; however, the extreme conditions might cause loss of vitamin C and phenolic compounds and also extraction [10,12].

Fermentation has not been the focus in many of the literature concerning the okra preservation methods, unlike dehydration and freezing, but there have been some recent works focusing on the possible changes that might occur in viscosity and also a concerning microbial activity and the fermentation and how it might affect extraction and also how it would affect phytochemicals and the size of the polymers and also the microbial activity that helps bring in new functional properties [13,14]. Because of the new information and diverse nature of the subject, it is important to refer to the use of fermentation.

This review aims to evaluate how drying, freezing, blanching with fermentation and other preservation methods, and also the recently developed fermentation methods, influence the okra physiochemical properties, phytochemical properties and the biological properties. Considerable focus will be placed on ensuring the conditions utilized for processing and the method of analyses are comparable in these studies.

2- Review methodology

The present study has been developed based on structured narrative review methodology after undergoing revision. In contrast to the first draft, which was developed based on the structured experimental review methodology, the revised version examined studies published between January 2014 and February 2026. In this version, four databases, Google Scholar, PubMed, Web of Science, and Scopus, were searched. "Okra" or

"Abelmoschus esculentus" and "drying" in combination with "freeze drying", "microwave drying", "heat pump drying," "vacuum drying", "freezing", "blanching", "fermentation", and "aged" as well as "antioxidants", "phenolics", and "flavonoids" were used in the search.

The following factors guided the data: raw material; cultivar/maturity; and pretreatment, as well as drying and freezing conditions, vacuum conditions, storage, fermentation, and relevant assays. The studies focusing only on phytochemical extraction without any studies on post-harvest processing, studies without measurable results on phytochemicals or bioactivity, and duplicate studies were not included in the comparative review. Due to significant diversity among the selected studies in regards to the sample, results, and assay, no meta-analysis was performed.

The comparison framework was used here to illustrate the processing factors. For drying studies, the factors noted were air temperature, microwave power, drying time, the use of vacuum, slice orientation/thickness, and blanching/pre-treatment chemicals. For freezing studies, the factors noted were the temperature, the time of storage, and protective antioxidants. For fermentation studies, if available, the process was described and the microorganisms used, as well as the model of fermentation and the substrates (seeds, juices, or polysaccharides) and the duration. The endpoints drawn for the analysis included the quantitative assays of total phenols (Folin-Ciocalteu method), total flavonoids (assay with aluminum chloride colorimetry), Vitamin C, and chlorophyll, β-carotene, loss of moisture, and water activity followed by assays to determine the coloration, the rehydration, viscosity, and assays for the antioxidant activity DPPH, ABTS, FRAP, and ORAC [2,3,8,12,15,16]. The comparative studies cited and associated factors are presented in Table 1 below.

Table 1. Summary of representative studies, processing conditions, analytical endpoints, and principal findings included in this review.

Study	Material and processing conditions	Main analytical endpoints	Principal finding
Aamir & Boonsupthip [4]	Fresh okra cubes dried by microwave at 440, 618, and 800 W to <10% moisture.	Drying kinetics, color, hardness, sensory quality.	800 W gave the shortest drying time, but higher power intensified color change.
Li et al. [6] and Wang et al. [7]	Comparative drying studies of sliced pods using hot-air, heat-pump, vacuum-freeze, and ultrasonic-assisted vacuum systems.	Drying time, color, rehydration, vitamin C, chlorophyll, TPC, antioxidant capacity, SEM.	Assisted or low-temperature systems reduced quality loss relative to conventional hot-air drying.
Samakradhamrongthai et al. [8]	Okra powder produced by hot-air drying (50–60 °C), microwave-vacuum drying (1800–3600 W), and freeze-drying.	Moisture, water activity, color, solubility, viscosity, TPC, TFC, FRAP, ABTS.	Freeze-drying gave the highest phytochemical retention; microwave-vacuum drying was the best quality–speed compromise.
El-Mesery & Elabd [9]	Okra pods dried by microwave, infrared, and convection hot-air under variable settings.	Drying kinetics, specific energy, color, shrinkage, rehydration.	Microwave drying achieved the most favorable time–quality balance among the tested regimes.
Al-Dabbas et al. [10]	Fresh, blanched, fried, frozen, dehydrated, and sun-dried okra, followed by storage up to 3 months.	TPC, TFC, reducing power, DPPH activity.	Blanched and frozen treatments retained phenolics and antioxidant

			activity better than dehydrated or sun-dried samples.
Rababah et al. [11]	Air-drying and freezing at −18 °C with or without Na_2SO_4 pretreatment, monitored for 0–6 months.	TPC, TFC, anthocyanins, antioxidant activity.	Freezing and Na_2SO_4 pretreatment improved retention during storage relative to air-drying.
Reid-Fitten et al. [12]	Control, steam-blanch, and hot-water blanch treatments combined with freeze-, hot-air-, and infrared-drying.	Moisture, water activity, phytonutrients, vitamin C, β-carotene, antioxidant activity.	Steam blanching followed by freeze-drying was the most effective preservation route overall.
Adetuyi & Ibrahim [13]; Wang et al. [14]	Spontaneous seed fermentation (24–120 h) and lactic fermentation of okra juice/polysaccharide systems.	Phenolics, flavonoids, vitamin C, FRAP/DPPH; molecular weight, viscosity, antioxidant and immunomodulatory properties.	Fermentation is promising but substrate-dependent and not yet directly comparable with whole-pod preservation studies.

Note: Fermentation studies were included as emerging evidence, but their substrates and endpoints differed from whole-pod drying and freezing studies, so they were interpreted qualitatively rather than ranked directly.

3- Results and comparative analysis

3.1 Dry Kinetics and Process Performance

The drying processes across the studies were highly variable depending on the amount of energy used and the pressure applied. Drying took the least time when using microwave systems. Fast reduction of the Okra moisture content was evident when using microwave systems as opposed to using hot air systems as was the case when applying both microwave treatment and vacuum systems [4,8,9]. Freeze drying was the most gentle process since sublimation of water occurs at a low vacuum. Hot air drying took several hours and was dependent on the different temperatures, different geometrical shapes, and different air [5,6,8]. Process engineering studies showed that heat-pump-assisted vacuum drying and ultrasound-assisted vacuum drying were more efficient than hot air drying and used less energy and improved the quality of the product. Based on the results, there is a contradiction of sorts in Okra drying where fast drying is likely to negatively affect the quality of the dried Okra.

3.2 Physicochemical quality and microstructure

All the effective drying methods were able to lower the moisture content and water activity values, ensuring microbiological safety. However, the method used, showed a considerable difference in product quality with respect to the physical attributes of the product. Freeze drying maintained the okra appearance most similar to that of fresh fruits, evidenced by the increase of lightness, retention of green color, minimum color change, and a porous structure that favors water absorption during the rehydration process [5,6,8]. The degradation of chlorophyll, browning, shrinkage, and degradation of the tissue, were mostly observed for the hot air and infrared drying, particularly after extended exposure to heat [5,6,9,12]. Even though drying time was considerably shorter than hot air drying, color protection was still dependent on the power used and the total residence time [4,8,9].

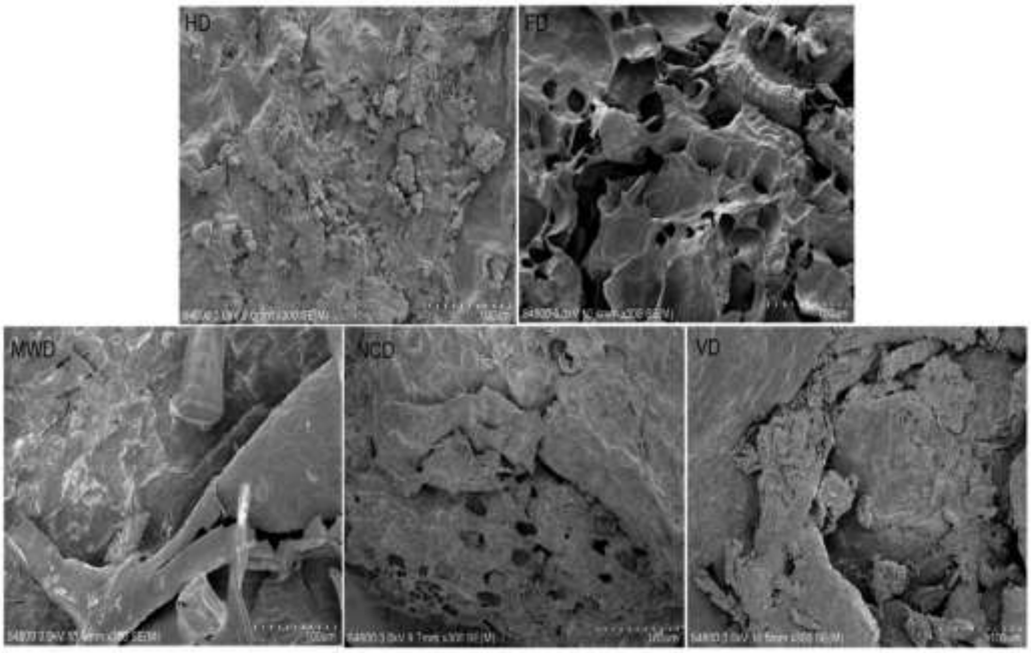

Figure 1. Standard micrographs obtained through scanning electron microscope of okra samples dehydrated using hot air drying (HD), freeze drying (FD), microwave drying (MWD), natural convection drying (NCD), and vacuum drying (VD).

Microstructure was a major factor affecting hydration characteristics. Freeze-drying produced a honeycomb structure with minimal shrinkage, while hot air and vacuum drying produced compact structures with diminished rehydration capacities [6-8]. As the functional properties of okra are significantly impacted by its mucilage structure, the structure's integrity was also preserved, resulting in improved rheological properties. The highest levels of viscosity were recorded for freeze-dried samples [8,17].

Table 2. Representative color parameters and solubility of okra powder obtained by different drying techniques (compiled from Samakradhamrongthai et al. [8]).

Drying Method	L* (Lightness)	a* (Greenness)	b* (Yellowness)	Solubility (%)
Fresh okra (control)	53.12 ± 0.45	−8.76 ± 0.12	30.63 ± 0.33	—
Freeze-drying (FD)	82.16 ± 0.15	−6.12 ± 0.05	32.12 ± 0.25	38.45 ± 0.23
Microwave-vacuum drying (MVD)	77.45 ± 0.32	−1.54 ± 0.08	28.45 ± 0.41	32.10 ± 0.45
Hot-air drying (HAD)	70.21 ± 0.54	+1.25 ± 0.12	25.67 ± 0.55	25.67 ± 0.55

Note: Higher L and more negative a* values reflect better retention of the characteristic green color of fresh okra.*

3.3 Phytochemical retention and antioxidant bioactivity

3.3 Phytochemical Retention and Antioxidant Bioactivity

Among the many treatments studied, freeze drying was shown to be the best treatment option for the preservation of total phenolic content (TPC), total flavonoid content (TFC), Vitamin C, chlorophyll, and antioxidants. Our results are consistent with existing literature on okra phytochemicals. HPLC-based okra studies show that isoquercitrin, rutin, protocatechuic acid, and quercetin derivatives contribute to the health benefits of okra [2,3].

In environmental conditions where hot-air drying is more favorable, there are higher losses of both heat-labile and water-soluble components, particularly with lengthy exposure times or higher temperatures [5,6,9]. Substantially less loss of okra powder phytochemicals was demonstrated in heat pump vacuum drying or microwave vacuum drying as compared to freeze drying [6-9]. Given that these methods are cheaper than freeze drying, for the production of high-value okra powders, these methods are more suitable especially when maximum phytochemical preservation is not the primary goal.

Phytochemical retention was assessed based on their antioxidant potential where DPPH, ABTS, FRAP, and ORAC assays were performed [8,10,12,15,16]. In the majority of studies, there was a tendency to use convergent methods for flavor or phenolic content by using aluminum chloride spectrophotometry or Folin-Ciocalteu, respectively, and at least one of the tests for antioxidant activity. The less exposure to heat and oxidative stress, the greater the functional activity of the phytochemicals.

3.4 Effect of pre-treatments and storage

Inactivating the browning and oxidation of phenolic enzymes during the drying process is one of the major demerits of blanching. But, the use of blanching can lead to the early leaching of the water-soluble compounds. Thus, the benefit will depend on the degree of blanching and also on the drying method. In the 2026 Foods article [12], steam blanching followed by freeze-drying, could retain enough phytonutrients, antioxidants, and vitamins.

On the other hand, compared to the air-drying method during the storage period, freezing was better for the preservation of phytochemicals, even though there was a continuous decline of the phytochemical content. In the ACS Omega journal, freezing and air-drying of okra resulted in a decline of TPC, TFC, anthocyanin, and antioxidant contents of the samples after six months, but the samples that were frozen were reported to have contained a higher concentration of the phytochemicals in comparison to the air-dried samples [11]. In the same article, it was reported that the use of sodium sulfate during storage resulted in a better preservation of the phytochemicals, due to a reduction of the oxidation [11]. Another 2023 Foods study also came to a similar practical conclusion [10].

3.5. Emerging Evidence on Fermentation

Compared to the drying and freezing of okra, literature on the fermentation of okra is scarce but to claim there is none is also inaccurate. Studies showed that fermentation (spontaneous for 120 h) of mature okra seeds enhanced the concentration of phenols, flavonoids, vitamin C, and increased their antioxidant activity, with remarkable change in antioxidant activity after 24 h of fermentation [13]. It was also reported that lactic acid fermentation of okra juice and its polysaccharides with Lactiplantibacillus plantarum showed the following changes: the product had a higher molecular weight, a higher total polysaccharide content with improved solubility and reduced viscosity, resulting in a product with enhanced immunomodulatory activity but decreased antioxidant activity [14].

From the available literature, fermentation cannot be shown to produce the same effect on the bioactivity of okra. It appears that the effect depends on a number of different factors: the whole fruit, seed, juice or polysaccharide and the microorganism; as well as the length of fermentation and the bioactivity test used. For the time being, it is also not feasible to compare fermentation with other processing methods of okra, such as drying and freezing, because the other methods have not been studied using the same sources and the same bioactivity endpoints.

4-Discussion

4.1 Mechanistic interpretation of processing effects

The discrepancies between drying methods and their preservation effects likely result from their ability to provide variations in water, heat, and the distribution of air, as well as the activity of enzymes. With freeze drying, heat destruction, the oxidation of color pigments, and the breakdown of structure are minimized because water is removed through sublimation under reduced temperature and subsustemic oxygen levels. This also leaves a porous structure, which is valuable for the preservation of okra because it aids rapid rehydration and preservation effects [5,8,12].

The effect of traditional air drying is opposite to that of freeze drying. The main mechanism of water removal is convection, which requires a long drying time. This increases the likelihood of degradation reactions of vitamin C and macromolecules responsible for viscosity and texture. Similarly, during drying, there may be changes to chlorophyll that result in the appearance of brown color [5,6,9]. The vacuum and the microwave drying methods fall between these extremes. Thermal stress may occur if drying is not well controlled, even with the rapid drying advantage of the volumetric heating principle. Heating methods utilizing vacuum, ultrasonic, and heat pump systems have potential advantageous effects and are promising methods [4,8,9].

Freezing does an excellent job of preserving phytochemicals only because it minimizes unfriendly chemical reactions. While a reaction may not be completely eliminated, the negative chemical interactions are kept in check with freezing. For this reason, freezing is an excellent preservation method, though not ideal for fixing products packaged to be used immediately at room temperature. Cell and texture damage often occurs with freezing and leads to the thawed product being unusable for the intended application. Depending on the intended use, thawed and dried products may be more appropriately frozen [10,11].

The introduction of preservation by fermentation changes the game entirely. Rather than preserving to simply stop the structural breakdown of the product, processes related to fermentation, such as acidification and hydrolysis, actually serve to modify the structure of the product. Okra fermentations have recently shown that while the technique offers a boost in phenolic content and provides immunomodulatory effects, it can also lead to a degradation of the product's antioxidant activity under particular situations [13,14]. This variation shows clearly that fermentation should not be place in the same category as freezing or drying.

4.2 Analytical Rigor and Standardized Reporting

The primary reason for needing a manuscript revision is ensuring accurately describing the exactness of the specified design and capacities. Each study used a different selection of cultivars, thicknesses of cut, stages of maturity, processing techniques, thermal treatments, and reporting bases (either fresh or dry weight). Each of these factors influences the conservation of the phytochemicals of interest [4-12]. Because of this, it is critical to take into account the dimensions of the sample, the reporting base, the severity of processing, the storage conditions, the solvent for extraction, and the analytical techniques for the determination of either the total antioxidant capacity or the concentration of individual phytochemicals. This is distinct from chromatographic or compound-specific analysis, and refers specifically to bulk Antioxidants [2,3,15,16].

4.3 Practical applications and industry relevance

The potential uses of high-quality freeze-dried or assisted-dried okra flour in various value-added products, such as functional food, soups, beverages, nutraceuticals, thickeners, and so on, show that these products would contain color, bioactive compounds, and mucilage. Where cold chain logistics in retail and food services is applied, freezing will continue to be the best preservation method for okra [10,11]. Other products, such as probiotics, sourdough, sauces, and polysaccharides, can also be made using fermentation to add value to them [13,14].

Research on consumer acceptance also has value. Preservation methods that will maintain the pleasing taste and green color of okra, as well as its good hydration, will likely be more successful than methods that rely on fermentation. Future studies, in addition to the phytochemical studies, should include shelf life studies, sensory studies, and techno-economic studies.

The main goal of the study is to have an identical cultivar, maturation index, cutting, and evaluation methods to compare the three processing methods used. Until that goal is achieved, the findings will be on the dominancy of one method over the others, particularly fermentation, and will only be preliminary.

5. Conclusion

The above review emphasizes how processing affects the physicochemical and functional qualities of harvested okra. Analyzing the techniques, freeze-drying is optimal as it retains phenolic and flavonoids, vitamin C, and chlorophyll; it also retains antioxidant activity, microstructure integrity, and mucilage-related functions. Microwave vacuum, heat pump, and assisted-drying techniques strike a balance between quality and efficiency, and seem to be appropriate drying methods, however, hot-air drying is more economical, but detrimental to sensitive compounds. Blanching may be a significant improvement, but freezing becomes the better preservative, as it retains the compounds of okra whens stored properly. fermentation also has potential, however, it lacks standardization and understanding.

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Compliance with ethical standards

This article lacks research involving human or animal subjects

6-References

[1] Durazzo, A., Lucarini, M., Novellino, E., Souto, E. B., Daliu, P., & Santini, A. (2019). Abelmoschus esculentus (L.): Bioactive components' beneficial properties—Focused on antidiabetic role—for sustainable health applications. Molecules, 24(1), 38. https://doi.org/10.3390/molecules24010038

[2] Shen, D.-D., Li, X., Qin, Y.-L., Li, M.-T., Han, Q.-H., Zhou, J., Lin, S., Zhao, L., Zhang, Q., Qin, W., & Wu, D.-T. (2019). Physicochemical properties, phenolic profiles, antioxidant capacities, and inhibitory effects on digestive enzymes of okra (Abelmoschus esculentus) fruit at different maturation stages. Journal of Food Science and Technology, 56(3), 1275-1286. https://doi.org/10.1007/s13197-019-03592-1

[3] Wu, D.-T., Nie, X.-R., Shen, D.-D., Li, H.-Y., Zhao, L., Zhang, Q., Lin, D.-R., & Qin, W. (2020). Phenolic compounds, antioxidant activities, and inhibitory effects on digestive enzymes of different cultivars of okra (Abelmoschus esculentus). Molecules, 25(6), 1276. https://doi.org/10.3390/molecules25061276

[4] Aamir, M., & Boonsupthip, W. (2017). Effect of microwave drying on quality kinetics of okra. Journal of Food Science and Technology, 54(5), 1239-1247. https://doi.org/10.1007/s13197-017-2546-3

[5] Huang, J., & Zhang, M. (2016). Effect of three drying methods on the drying characteristics and quality of okra. Drying Technology, 34(8), 900-911. https://doi.org/10.1080/07373937.2015.1086367

[6] Li, H., Xie, L., Ma, Y., Zhang, M., Zhao, Y., & Zhao, X. (2019). Effects of drying methods on drying characteristics, physicochemical properties and antioxidant capacity of okra. LWT - Food Science and Technology, 101, 630-638. https://doi.org/10.1016/j.lwt.2018.11.076

[7] Wang, H., Zhao, Q., & Zhao, B. (2019). Comparison of drying methods on drying efficiency and physicochemical quality of okra (Abelmoschus esculentus) cultivated in China. Journal of Food Process Engineering, 42(6), e13163. https://doi.org/10.1111/jfpe.13163

[8] Samakradhamrongthai, R. S., Nortuy, N., Jannu, T., Supawan, T., Chanakun, P., Yimkaew, Y., & Renaldi, G. (2022). Influence of three drying methods on physicochemical properties of okra (Abelmoschus esculentus L.) powder. Journal of Food Processing and Preservation, 46(3), e16381. https://doi.org/10.1111/jfpp.16381

[9] El-Mesery, H. S., & Elabd, M. A. (2021). Effect of microwave, infrared, and convection hot-air on drying kinetics and quality properties of okra pods. International Journal of Food Engineering, 17(11), 909-926. https://doi.org/10.1515/ijfe-2021-0125

[10] Al-Dabbas, M. M., Moumneh, M., Hamad, H. J., Abughoush, M., Abuawad, B., Al-Nawasrah, B. A., Al-Jaloudi, R., & Iqbal, S. (2023). Impact of processing and preservation methods and storage on total phenolics, flavonoids, and antioxidant activities of okra (Abelmoschus esculentus L.). Foods, 12(19), 3711. https://doi.org/10.3390/foods12193711

[11] Rababah, T. M., Al-U'datt, M. H., Angor, M., Gammoh, S., Abweni, F., Magableh, G., Almajwal, A., Yücel, S., AL-Rayyan, Y., & AL-Rayyan, N. (2023). Effect of drying and freezing on the phytochemical properties of okra during storage. ACS Omega, 8(38), 34448-34457. https://doi.org/10.1021/acsomega.3c02560

[12] Reid-Fitten, M. L., Cotton, C. P., Min, B. R., Nindo, C. I., & Williams, Z. F. (2026). Effects of thermal pre-treatments and drying processes on the retention of phytonutrients, vitamins, and antioxidant activity in dried okra (Abelmoschus esculentus L.). Foods, 15(2), 311. https://doi.org/10.3390/foods15020311

[13] Adetuyi, F. O., & Ibrahim, T. A. (2014). Effect of fermentation time on the phenolic, flavonoid and vitamin C contents and antioxidant activities of okra (Abelmoschus esculentus) seeds. Nigerian Food Journal, 32(2), 128-137. https://doi.org/10.1016/S0189-7241(15)30128-4

[14] Wang, X., Hu, K., Chen, Y., Lai, J., Zhang, M., Li, J., Li, Q., Zhao, N., & Liu, S. (2024). Effect of Lactiplantibacillus plantarum fermentation on the physicochemical, antioxidant activity and immunomodulatory ability of polysaccharides from Lvjian okra. International Journal of Biological Macromolecules, 257(Pt 1), 128649. https://doi.org/10.1016/j.ijbiomac.2023.128649

[15] Prior, R. L., Wu, X., & Schaich, K. (2005). Standardized methods for the determination of antioxidant capacity and phenolics in foods and dietary supplements. Journal of Agricultural and Food Chemistry, 53(10), 4290-4302. https://doi.org/10.1021/jf0502698

[16] Karadag, A., Ozcelik, B., & Saner, S. (2009). Review of methods to determine antioxidant capacities. Food Analytical Methods, 2(1), 41-60. https://doi.org/10.1007/s12161-008-9067-7

[17] Yuan, Q., He, Y., Xiang, P.-Y., Huang, Y.-J., Cao, Z.-W., Shen, S.-W., Zhao, L., Zhang, Q., Qin, W., & Wu, D.-T. (2020). Influences of different drying methods on the structural characteristics and multiple bioactivities of polysaccharides from okra (Abelmoschus esculentus). International Journal of Biological Macromolecules, 147, 1053-1063. https://doi.org/10.1016/j.ijbiomac.2019.10.073