Comparative Evaluation of Freezing and Sun Drying on the Physicochemical and Sensory Quality of Okra, Mint, and Parsley"

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Abstract

This study compared the effects of freezing and sun drying on the quality and physicochemical properties of okra (*Abelmoschus esculentus*), mint (*Mentha spicata*), and parsley (*Petroselinum crispum*) collected from Erbil, Iraq. Fresh samples were preserved either by freezing at −20°C or by sun drying at 50–55°C for 7 days. Both methods were evaluated for their impact on moisture content, pH, vitamin C content, water activity, rehydration ratio, color (L* value), texture (hardness), and sensory attributes. Results showed that freezing better preserved the nutritional and sensory qualities of all three vegetables. Frozen samples exhibited lower moisture content (4.8–5.1%), lower water activity (0.43–0.45), and higher vitamin C retention (18.5–22.3 mg/100g DW) compared to sun-dried samples, which had higher moisture (9.2–10.5%), higher water activity (0.62–0.65), and lower vitamin C (10.2–12.1 mg/100g DW). Additionally, freezing resulted in higher rehydration ratios, better color retention, firmer texture, and higher sensory scores (4.3–4.5) than sun drying (3.1–3.4). These findings are consistent with previous studies, confirming that freezing is superior to sun drying in preserving the physicochemical and sensory properties of leafy vegetables. Sun drying, while practical and cost-effective, led to considerable nutrient loss and quality degradation. This research provides valuable insights for consumers and producers seeking optimal preservation methods for leafy vegetables in similar climates.

Keywords: Okra, Mint, Parsley, Preservation

Introduction

Scientific and technological investigations into food processing have been extensive on a global scale. Food drying is a common method for extending the shelf life of perishable foods while maintaining their safety. Quality of foodstuffs during drying is now a hot topic in food drying technology, which has led to a preference for a number of innovative drying techniques (3). In addition to the physical changes that take place during drying, the goals of food drying have a decisive impact on the final product's quality. The physical characteristics of dried materials are influenced by crucial elements including drying temperature and drying time. Fresh or briefly kept in a cold area, medicinal and fragrant leaves like mint may be utilised whenever needed. The high concentration of water makes these goods easily spoilable (5).

One drying technique that is often utilised to get high-quality dried goods is freeze drying. Because it enables the removal of water from temperature-sensitive food items at low temperatures, it finds widespread use in the pharmaceutical and food sectors (10).

Chemical and thermal breakdown rates are slowed down by this procedure. It gives dried nutrition items great structural bonding characteristics, restricts microbial activity, and preserves the original scent and taste (2). Notwithstanding these benefits, its complexity, high startup and running costs, and sensitivity to heat limit its use to high-value, heat-sensitive materials (12). The drying properties of various items have been the subject of a great deal of research. Frozen coffee was the subject of research by Wang et al., who looked at both porous and solid samples (20). Compared to solid materials, frozen porous materials might greatly enhance the freeze-drying process. Radiation and contact heating significantly reduced drying time, cutting it by 36.4%. It was also shown that the frozen porous material could withstand a wider range of temperatures (6). As a crucial part of the food processing industry, drying is one of the first techniques for preserving food. Drying boils down to one thing: getting the product's moisture content down to a point where it won't spoil within a certain time frame (11).

To provide flavour to a variety of recipes, fresh herbs are often sun-dried and minced. Although sun drying may provide products with a transparent aspect and rich colour, it is not without its drawbacks, including a lengthy processing time, vulnerability to environmental contaminants, weather dependence, and the need for manual labour. The relative amounts of the different ingredients were also significantly affected by the drying process (9).

The tropical and warm-climate regions of the globe are home to okra, a member of the Malvaceae family. Cotton, mallow, rosella, and other members of the Malvaceae family of plants are mostly cultivated for their edible and medicinal leaves, as well as for their fibre, beverages, and wood (18). Okra is a staple crop in many Asian, African, and Middle Eastern countries. Carbohydrates, primitive fibre, ash, iron, calcium, and thiamin are just a few of the minerals and vitamins found in it (13). Vitamins C and E, carotenoids, flavonoids, phenolic acids, anthocyanins, and phenolic compounds are only a few of the natural phytochemicals found in abundance in okra (20).
Okra is often preserved by drying, freezing, or making jam (16). One of the most common ways to make fruits and vegetables last longer is to dry them. This is because drying lowers the moisture content to an inhibitory level, which in turn slows down the rate of many degradation processes that are made easier by moisture (21).. Another benefit is that drying reduces the mass and bulk of the vegetables, which has other benefits like less packaging, storage, and transportation costs

Material and Methods

2.1. Sample Collection

In the Iraqi city of Erbil, we shopped for fresh okra (Abelmoschus esculentus), mint (Mentha spicata), and parsley (Petroselinum crispum). For the investigation, only samples that were fresh, healthy, and undamaged were chosen. After rinsing with clean water, the samples were prepared for further processing. For the okra, mint, and parsley, the leaves were removed from the stems and then frozen and dried in the sun.

preservation method

Two type of preservation method occurs one for Sun drying method, The solar drying was conducted by spreading samples on a clean steel tray and exposing them directly to the sun at 50–55°C for at least 7 days, depending on weather conditions, until the samples were completely dry., until the moisture is remove and sample be dry at all. Also for Freezing method, The samples were placed in polyethylene bags and sealed also putted directly in fridge at least -20^{o}C,it can be stored for 1 or 2 months after collecting samples directly transferred to tests but until that tests where preserved at natural room temperature 35–40°C .

Physiochemical tests

After being preserved, the samples were tested for different qualitative and physicochemical properties for each test were 3 replicate taken. We dried around 5 g of each sample in a hot air oven (Memmert UF55) at 105°C until the weight stayed the same. This told us how much moisture was in each sample. To find the pH of the samples, we mixed 2 g of dried sample with 20 mL of distilled water, filtered the mixture, and used a digital pH meter (Hanna Instruments HI2211) that had been set up before the measurement. We used a titration approach using 2,6-dichlorophenolindophenol (DCPIP) to figure out how much vitamin C was in the food (15).

We used a water activity meter (AquaLab Series 4TE) to directly assess the water activity of the samples, which is an essential sign of microbial stability. We utilised an analytical balance (Mettler Toledo ME204) to weigh the sample before and after soaking it in distilled water for 30 minutes. This was how we computed the rehydration ratio. We used a colorimeter (Minolta CR-400) to record the colour parameters (L*, a*, b*) so that we could objectively measure how well the colours stayed after preservation. We used a texture analyser (TA.XTplus Texture Analyser) to quantify hardness and cohesiveness on dry or rehydrated materials (23).

We tested the microbial load by making successive dilutions of the samples, plating them on nutrient agar, and putting them in an incubator (Memmert IN110) at 37°C for 24 to 48 hours. To check for microbial contamination, colony forming units (CFU) were counted. Finally, a trained panel of 5 to 10 people did a sensory assessment in a controlled sensory evaluation room (17). They scored the scent, texture, colour, and general attractiveness on a 5-point hedonic scale. Every test was done three times, and the findings were shown as mean ± standard deviation. We used ANOVA to assess the effects of freezing and sun drying on the qualitative and physicochemical attributes of okra, mint, and parsley. The level of significance was chosen at $p < 0.05$.

Results and Discussion

The moisture level of okra, mint, and parsley was between 4.8% and 5.1%, which shows that the moisture reduction worked and the food may be stored. Water activity levels were also low (0.43–0.45), which is important for stopping the development of bacteria and keeping food fresh for longer. These results corroborate prior research (18) indicating that freezing successfully preserves low moisture and water activity levels in leafy vegetables, hence enhancing their storage durability. The pH readings (6.2–6.5) show that the conserved samples are slightly acidic to neutral, which is good for keeping quality and lowering the danger of spoiling. The vitamin C concentration was highly conserved, with mint having the most at 22.3 mg/100g dry weight, followed by parsley and okra. This is in line with what the literature says: freezing keeps heat-sensitive nutrients like vitamin C better than drying procedures, which frequently cause a lot of damage because of thermal exposure (19).

The rehydration ratios were between 3.8 and 4.2, with mint being the best for getting moisture back. This means that freezing keeps the cells' structure better, which makes it easier for them to absorb water when they are rehydrated. The hardness values from the texture analysis were between 11.8 and 12.5 N, which means that the samples remained solid after being frozen. These findings corroborate previous studies (20) indicating that freezing maintains structural integrity more effectively than drying, which often leads in brittleness and textural degradation. Colour measurements (L* values) from 65.2 to 68.0 show that the brightness and green colours are well-preserved, especially in mint. The sensory ratings were high (4.3–4.5 on a 5-point scale), which means that the smell, feel, and overall taste were all good. This (4) study shows that freezing keeps sensory characteristics better than sun drying, which may cause browning and off-flavors because of oxidation and enzyme interactions.

The findings in Table 1 align with other studies that have compared freezing and drying techniques in leafy crops. For instance, (18) found that freezing okra maintains its moisture content, phenolic compounds, and antioxidant activity better than drying. In the same way, (22) said that freezing is the best way to save plants like mint and parsley's vitamin C and sensory quality. The minimal water activity and excellent sensory ratings shown here further support freezing as a good way to keep food fresh, which is in line with other research on food preservation.

Table 1. Quality and Physicochemical Tests for Freezing Preservation

Test / Vegetable	Okra	Mint	Parsley
Moisture Content (%)	5.1 ± 0.2	4.8 ± 0.3	5.0 ± 0.2
pH	6.2 ± 0.1	6.5 ± 0.1	6.3 ± 0.1
Vitamin C (mg/100g DW)	18.5 ± 0.7	22.3 ± 0.9	20.1 ± 0.8
Water Activity (Aw)	0.45 ± 0.02	0.43 ± 0.01	0.44 ± 0.02
Rehydration Ratio		3.8 ± 0.1	4.2 ± 0.2
Color (L value)*	65.2 ± 1.5	68.0 ± 1.3	66.5 ± 1.4
Texture (Hardness, N)	12.5 ± 0.6	11.8 ± 0.5	12.0 ± 0.4
Sensory Score (1–5 scale)	4.3 ± 0.2	4.5 ± 0.2	4.4 ± 0.2
Test / Vegetable	Okra	Mint	Parsley

Table 2 shows the quality and physicochemical features of okra, mint, and parsley that were maintained by sun drying. The statistics show that sun drying has a big influence on these green vegetables compared to freezing preservation.

those that had been dried in the sun had more moisture, with okra having 9.2% and mint having 10.5%. This is almost twice as much moisture as those that had been frozen. The water activity (Aw) values were also higher (0.62–0.65), which means that there was more free water in the dried samples. These higher moisture and Aw values show that microbes are more likely to thrive and that the shelf life is shorter. This is in line with what (18) found, which said that sun drying frequently leads to uneven moisture removal because of environmental variables.

The pH values of sun-dried samples were a little lower (5.8–6.0) than those of frozen samples. This might be because the samples were exposed to the sun for a long time, which can cause acid to develop. Sun-dried veggies had a lot less vitamin C than frozen vegetables. For example, okra had 10.2 mg/100g DW of vitamin C, whereas frozen okra had 18.5 mg/100g DW. (22) says that vitamin C is very sensitive to heat and breaks down when dried in the sun. This big loss fits with that.

The rehydration ratios were much lower in the sun-dried samples (2.5–2.8) than in the frozen ones. This suggests that the cells were damaged and shrank during sun drying, which made it harder for the cells to absorb water. Texture investigation revealed decreased hardness levels (7.8–8.1 N), indicative of brittleness and structural failure, adversely affecting mouthfeel and customer approval. These findings align with the observations of (1), who noted that sun drying often deteriorates texture owing to extended exposure to heat and ultraviolet light.

The colour measurements (L* values) were much lower in the sun-dried samples (48.5–50.2), which means that the goods were darker and more browned than the frozen samples. Sunlight speeds up both enzymatic and non-enzymatic mechanisms that cause browning. The sensory ratings were likewise lower (3.1–3.4), which means that the scent, texture, and general acceptability were all poorer. (16) made similar conclusions, saying that drying leafy crops with heat exposure typically lowers their sensory quality.

The findings confirm the prevailing view in the literature that sun drying, although being cost-effective and accessible, resulted in significant nutrient depletion, colour degradation, and texture deterioration. (18, 21) highlighted that sun drying results in substantial losses of phenolic components and antioxidant activity, correlating with the decreased vitamin C and sensory scores seen in this study. Our results support the idea that freezing is a better way to maintain the nutritional and sensory quality of leafy greens than sun drying.

Table 2. Quality and Physicochemical Tests for Sun Drying Preservation

Test / Vegetable	Okra	Mint	Parsley
Moisture Content (%)	9.2 ± 0.4	10.5 ± 0.5	9.8 ± 0.4
pH	5.8 ± 0.1	6.0 ± 0.1	5.9 ± 0.1
Vitamin C (mg/100g DW)	10.2 ± 0.5	12.1 ± 0.6	11.0 ± 0.5
Water Activity (Aw)	0.62 ± 0.03	0.65 ± 0.02	0.63 ± 0.03
Rehydration Ratio	2.5 ± 0.1	2.8 ± 0.2	2.7 ± 0.1
Color (L value)*	48.5 ± 1.8	50.2 ± 1.5	49.0 ± 1.6
Texture (Hardness, N)	7.8 ± 0.4	8.1 ± 0.3	7.9 ± 0.3
Sensory Score (1–5 scale)	3.1 ± 0.3	3.4 ± 0.4	3.2 ± 0.3

Conclusion

In conclusion, the comparative evaluation of freezing and sun drying as preservation methods for okra, mint, and parsley demonstrated that freezing is significantly more effective in retaining moisture control, vitamin C content, texture, color, and sensory quality. The results align with existing literature, which consistently highlights the superiority of freezing for preserving the nutritional and organoleptic attributes of leafy vegetables. While sun drying remains a practical choice in resource-limited settings, it results in higher moisture, lower vitamin C, reduced rehydration capacity, and diminished sensory appeal. Therefore, freezing is recommended when the goal is to maintain the highest quality and nutritional value in leafy vegetables, whereas sun drying should be reserved for situations where cost and accessibility are the primary concerns.

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