

PAPER 48- COMPARATIVE ANALYSIS OF SUN, SOLAR, AND OVEN DRYING TECHNIQUES ON SELECTED ATTRIBUTES OF HONEY-TREATED BANANA FRUIT SLICES

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ABSTRACT

This study investigated the effects of three drying methods (sun, solar, and oven drying) on the proximate and vitamin qualities of dried honey-treated ripe banana slices. Samples of 5mm-sized, firmly-ripe banana slices were soaked in 0.25% v/v honey solution for 4 minutes, drained, and divided into three groups. The samples were subjected to sun drying, solar drying, and oven drying (at 65°C) until constant moisture content was reached. The results showed that the banana sample dried in the oven has the highest values of 5.00%, 2.14%, and 5.60% for fat, protein, and ash respectively. However, both sun and solar drying methods recorded slightly lower moisture content (5.20%) than oven drying (5.40%). Also, higher vitamin C (81.70 mg/100g) and β -carotene (1361.16 ug/100g) contents were observed in the oven-dried banana sample. The results suggest that honey treatment, coupled with oven drying, is an effective combination for preserving the quality of banana slices. Oven drying demonstrated superiority in terms of vitamin C, β -carotene, and some proximate retention. The findings emphasize the potential of honey as a natural preservative and oven drying as an efficient method for producing high-quality dried banana slices. This research provides valuable insights for the food industry, offering an alternative approach for reducing postharvest losses of ripe bananas and enhancing the quality of dried banana slices through honey pre-treatment and oven drying.

KEYWORDS: Banana, Drying methods, Honey-treated, Proximate qualities, Vitamin C, β -carotene.

1. INTRODUCTION

Banana (*Musa spp.*) is among the major tropical fruits that are commonly consumed in many countries of the world. Bananas are golden yellow with smooth, thin skin when fully ripe and they possess an extremely sweet and fragrant aroma. The typical fruit's length is an average of 6–12 cm with a diameter ranging between 3-4 cm and has contributed to food security and income generation in many communities around the globe (Maseko *et al.*, 2024; Wong *et al.*, 2017). Bananas are full of a whole lot of nutritional goodness because it is a rich source of dietary fiber, carbohydrates, vitamins (A, B, C, E, β -carotene), minerals, oligosaccharides, and phenolic compounds such as catechin, epicatechin, epigallocatechin, gallic acid, lignin, tannins, and anthocyanins (Ghimire *et al.*, 2021; Guiné *et al.*, 2015). The presence of these compounds makes the consumption of banana fruit beneficial to the human body and helps to prevent various disorders such as bad breath, colon cancer, diabetes, intestinal disorders constipation, morning sickness, hemorrhoids, obesity, high blood pressure, broken capillaries, and lots more (Ghimire *et al.*, 2021; Puangsuwan *et al.*, 2021). However, with all the benefits of banana fruit, it has a short shelf-life and is highly perishable. In fact, (Elangovan and Natarajan, 2021) stated that the average shelf-life of bananas is 2 to 9 days when stored in a refrigerator, 2 to 3 months in a freezer, and 6 to 12 months when dried. Therefore, to preserve the bioactivity of banana fruit and enhance its shelf-stability, drying is paramount.

Drying, reported to be one of the oldest and most widely used methods of preserving fruits, is the reduction in the moisture level of a biomaterial to a level that hinders the activities of spoilage microorganisms through the application and circulation of heated air (Citra *et al.*, 2021; Radojčin *et al.*, 2021). Drying prevents microbial spoilage, reduces packaging and transportation costs, facilitates product handling, enhances versatility, and ensures the stability of fruits during storage. It also helps in tackling the problem of perishability and seasonality of fruits, making them available for consumption all year round (Ghasemi-Varnamkhasti and Aghbashlo, 2014). Several drying methods have been reported by different researchers for the preservation of banana fruits and these include superheated steam drying (Hamawand *et al.*, 2014), Osmotic dehydration (Kumari and Samsher, 2015), microwave vacuum drying, microwave multi-flash drying and freeze-drying (Monteiro and Carcio, 2016), spray drying (Wong *et al.*, 2017), thin-layer convective drying (Seyedabadi *et al.*, 2018), fixed-bed tray drying (Ferreira

and Freitas, 2019), foam mat drying (Noordia *et al.*, 2020), hybrid infrared-hot air drying (Puangsuwan *et al.*, 2021), infrared/convection drying (Badr *et al.*, 2022) and solar drying (Nguyen *et al.*, 2023).

Oftentimes before the drying process, many researchers carry out pre-drying treatments on biomaterials especially fruits to inhibit enzymatic browning and prevent undesirable chemical reactions that cause many adverse changes during and after drying. For instance, 0.5% sodium metabisulfite and 0.5% calcium chloride were used as pretreatments for tomato (Mwende *et al.*, 2018), ultrasound pretreatment for garlic slices (Bozkir *et al.*, 2019), lemon juice, salt solution dips, and hot water blanching were used by (Dereje and Abera, 2020) as pretreatments for mango, osmotic pretreatment for African star apple (Bolarinwa and Ajetunmobi, 2020), ascorbic acid dip, honey dip, and steam blanching were used for pawpaw (Adepoju *et al.*, 2021), blanching, citric acid solution, lemon juice, brine solution, and rice rinse water for banana flower powder (Jha *et al.*, 2021), soaking, blanching for mango kernel (Zikri *et al.*, 2022). These pretreatments have been observed to have some desirable effects on the qualities of dried food products, to shorten the drying time, and to reduce the energy consumption of the drying process (Radojčin *et al.*, 2021). To this end, therefore, this study aimed to investigate the influence of sun, solar, and oven drying methods on proximate and vitamin contents of dried honey-treated banana fruit slices.

2. MATERIALS AND METHODS

2.1 Materials and Pretreatment

Fresh firmly ripe banana fruits and the honey used for the pretreatment of the fruit slices were procured from a local fruit market and a pharmaceutical outfit respectively, both in Minna, Niger State. The banana fruits were inspected, sorted, washed, hand-peeled, and cut into about 5 mm thick slices to enhance fast and uniform drying. The sliced fruit samples were pretreated with a honey solution of 0.25% v/v (one part honey to four parts water) by dipping the fruit slices into the solution immediately after slicing and left for 4 minutes and afterward drained well before drying. The honey-treated fruit samples were then subdivided into three, 400 g each. There were three samples of untreated banana slices, 400g each, to serve as the control for the three drying methods.

2.2 Drying procedure

Sun drying of the fruits was carried out by placing the honey-treated sliced banana fruits on netted drying trays in a thin layer. The trays were placed on a raised platform, which helped to facilitate adequate air circulation around the slices, and left in the sun to dry. The slices were weighed at 1-hour intervals until a constant weight was obtained after 15 hours. Solar drying was carried out with the aid of a solar dryer (in the Department of Agric and Bioresources Engineering Lab) consisting of a wooden cabinet with trays on which the treated sliced fruit were placed. The dryer was put in the sun and solar rays were trapped with the help of the solar collector of the dryer. The samples were weighed at intervals until a constant weight was obtained after 12 hours. Oven drying experiments were done using a fan-aerated (Galen Kamp) oven. The oven was preheated and calibrated to a temperature of 65 °C before the banana slices were placed into it and the fruit were weighed at 1-hour intervals until constant weight was obtained after 9 hours.

2.3 Quality Analysis

Proximate analysis for the dried banana fruit samples was determined according to AOAC standard procedures. Moisture content was calculated using the oven dry method, ash content was determined with the use of a Muffle furnace; the Kjeldahl method was used for protein content determination, Soxhlet fat extraction method, and Hennenberg, Stohmann, and Rantenberg method was used to determine fat and fibre contents respectively while carbohydrate content was calculated by difference. Vitamin C and β -carotene contents of the dried fruit were determined by the titration method of Osborne and Voost and the spectrophotometric method based on Ultraviolet (UV) inactivation respectively, as outlined in (AOAC, 2005).

2.4 Statistical Analysis

SPSS 20.0 software was used to carry out the Analysis of Variance (ANOVA) tests for all experiments at a 0.05% level of significance and the Duncan Multiple Range Test (DMRT) was used to determine the differences in the

mean of the treatments. Also, drying curves that show the rate of drying of the fruit samples were plotted using the Excel software.

3. RESULTS AND DISCUSSIONS

3.1 Drying curve for dried honey-treated banana fruit

The moisture content of the dried fruits was plotted against the time of drying to generate the drying curves for honey-treated (Figure 1) and untreated (Figure 2) banana slices dried with different drying methods. The results showed that as the drying time increased, the moisture content of the fruit slices decreased until a constant moisture content is reached. It was deduced from the drying curve that the moisture content of fruit slices dried in the oven reduced and reached a constant moisture content faster than the other two drying methods. This certainly was because the oven drying method is dependent on a power source other than the sun, as in the case of sun and solar drying methods. Also, the honey pretreatment applied to the banana slice did not affect the drying time, as both the treated and untreated samples had the same drying time. However, a little difference was observed in the drying curves, especially at the initial stage of the drying process. A similar trend of moisture content/ratio-drying time curves was reported for different drying air temperatures for dried banana (Cristina Pagliari Braga *et al.*, 2021; Macedo *et al.*, 2020) and for different pre-treatments on the qualities and storage life of a dried banana (Nguyen *et al.*, 2023).

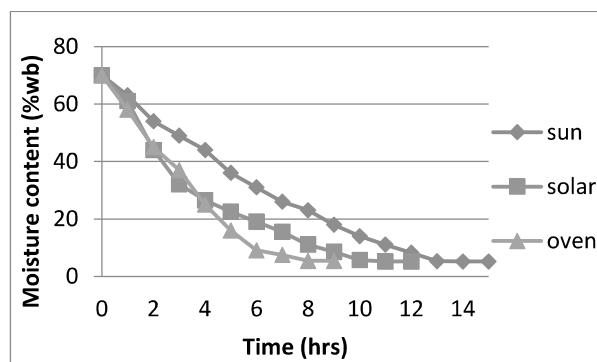


Figure 1: Drying curves of dried honey-treated banana samples across the three drying methods

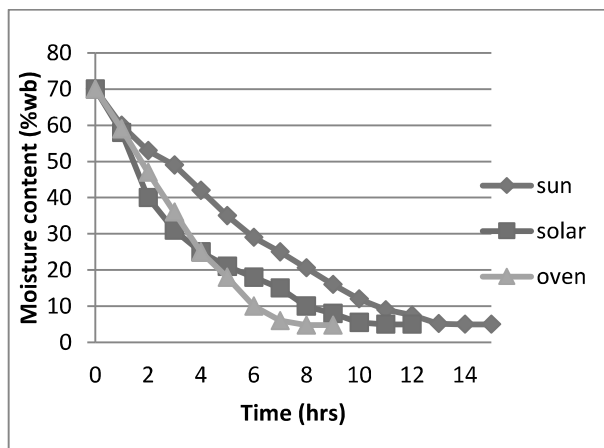


Figure 2: Drying curves of dried untreated (control) banana samples

3.2 Proximate qualities of samples as influenced by drying methods

The proximate qualities of the dried honey-treated banana samples were analysed and the results are shown in Table 1. Slightly lower values of moisture contents were obtained in the sun and solar drying methods than in the

oven drying method. This may be because oven-dried samples are hygroscopic and have gained moisture from the environment when exposed. However, these moisture contents were not significantly different and were still within the safe level for dried fruits. (Hussain *et al.*, 2020) reported 4.6% and 4.81% moisture content for 5mm and 7mm thick dried banana slices pretreated with honey juice, which is lower than the ones obtained in this study. However, higher values of moisture contents were reported for bananas dried with different air temperatures (Macedo *et al.*, 2020) and dried banana pretreated with food additive and antioxidant solution (Ferreira and Freitas, 2019). The fat contents of the dried honey-treated banana slices increased in the order: sun dried<solar dried<oven dried banana slices. This implies that the banana sample dried in the oven had the highest fat content (5.00%) compared to the other drying methods. The values of fat obtained in this study are higher than those recorded for pretreated dried mango (Dereje and Abera, 2020) and dried stinging nettle leaves (Shonte *et al.*, 2020). Banana slices dried in the oven recorded the highest protein content of 2.14% when compared with 1.13% and 1.16% respectively for sun and solar-dried slices. (Dereje and Abera, 2020) reported 2.71% for oven-dried mango whereas (Shonte *et al.*, 2020) reported 28.8% for dried stinging nettle leaves. The oven-drying method had the highest ash content with a value of 5.60%. This value is higher than the 1.26% reported for oven-dried malbhog banana slices and pulp (Dadhaneeya *et al.*, 2023) and 2.50% for keitt mango sliced chips (Techane, 2022). The highest value of crude fibre (0.43%) and carbohydrate (86.06%) were recorded in solar-dried and sun-dried banana samples respectively. However, (Shonte *et al.*, 2020) reported a higher value of crude fibre (28.8%) but a lower value of carbohydrate (26.1%) in their research on the effect of drying methods on the chemical composition and antioxidant activity of underutilized stinging nettle leaves.

Table 1: Proximate Qualities of Honey-Treated Dried Banana Samples

Samples	MC (%)	Fat (%)	Protein (%)	Ash (%)	Fibre (%)	Carbohydrate (%)
SUC	5.00 ^a	3.50 ^a	1.33 ^a	3.20 ^a	0.36 ^a	86.61 ^b
SUD	5.20 ^b	4.00 ^a	1.13 ^a	3.20 ^a	0.41 ^b	86.06 ^b
SOC	5.00 ^a	4.50 ^c	0.95 ^a	2.40 ^a	0.41 ^{ab}	86.74 ^b
SOD	5.20 ^b	4.50 ^b	1.16 ^a	3.00 ^a	0.43 ^b	85.71 ^b
OVC	5.00 ^a	3.00 ^a	1.19 ^a	3.60 ^{ab}	0.32 ^a	86.89 ^b
OVD	5.40 ^b	5.00 ^c	2.14 ^a	5.60 ^b	0.36 ^a	83.50 ^a

Values followed by the same letter in the same column are not significantly different at P < 0.05

SUC- Sun Drying Control; SUD- Sun Drying; SOC- Solar Drying Control; SOD-Solar Drying; OVC- Oven Drying Control; OVD- Oven Drying

3.3 Influence of drying methods on vitamin C and β -carotene contents of samples

The influence of drying methods on the vitamin C and β -carotene contents of the honey-treated banana samples was analysed and the results are shown in Table 2. It was observed that the sun drying method had the lowest value of both vitamin C (79.32mg/100g) and β -carotene (614.85 μ g/100g) contents among the three methods while the oven drying method recorded the highest values (81.70mg/100g; 1361.16 μ g/100g). This may be due to the exposure of the banana slices to the direct light of the sun in the sun and solar drying methods, as these vitamins are highly prone to oxidative degradation in the presence of heat, light, and oxygen (Goztepe *et al.*, 2022). The values of vitamin C obtained in this study are in the same range as 85.56mg/100g reported by Hussain *et al.*, (2020) for honey-treated dried banana slices but higher than 68.5 mg/100g and 65.3 mg/100g reported for oven-dried stinging nettle and spinach respectively (Shonte *et al.*, 2020). However, higher values of β -carotene (52504 μ g/100 g and 40847 μ g/100 g) were reported by the same authors. Drying conditions could have a great effect on heat and light labile β -carotene and ascorbic acid.

Table 2: Vitamin C And β -carotene Contents of Dried Honey-Treated Banana Samples

Samples	Vitamin C(mg/100g)	β -carotene (μ g/100g)
SUC	66.00 ^a	986.54 ^a
SUD	79.32 ^a	614.85 ^a
SOC	70.95 ^a	1396.95 ^b
SOD	80.01 ^{ab}	1227.25 ^b
OVC	72.06 ^a	1946.91 ^b
OVD	81.70 ^b	1361.16 ^b

Values followed by the same letter in the same column are not significantly different at $P < 0.05$.

SUC- Sun Drying Control; SUD- Sun Drying; SOC- Solar Drying Control; SOD-Solar Drying; OVC- Oven Drying Control; OVD- Oven Drying

4. CONCLUSION

This study investigated the influence of drying methods on some qualities of dried honey-treated banana fruit slices. It can be concluded from the study that the oven-drying method is most suitable for drying honey-treated banana slices as it helped to retain the proximate properties of the dried banana and the moisture content was within the safe storage moisture contents for dried fruits. Also, higher vitamin C and β -carotene contents were observed in the oven-dried banana sample when compared with the other drying methods. Therefore, the oven-drying method can be used to preserve ripe banana fruit from spoilage. Further studies can be carried out by using more advanced drying methods with lower drying air temperature and/or resident time such as freeze and spray drying for the preservation of bananas.

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