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Optimisation of drying characteristics in the preparation of banana strips for the production of energy rich nutribar

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Abstract
The researcher picked the delicious Karpooravalli variety from a tree in the Tamilnadu Agricultural University's orchard. Overripening occurred after they were purchased at a ripe stage. To make nutribars, we bought some foxtail millet from the grocery store and dried it using our solar drier and our tray dryer. A tray dryer is a common kind of dryer that stacks individual drying chambers and trays on a trolley. Tray dries are often employed in industrial settings where drying and heating play important roles. The trays are used to dry either solid or liquid substances. A radiator coil or electric heater is used to circulate hot air through the trays, so transferring heat. The installed blower fans aid in the transmission and circulation of heat. The tray dryer's control panel regulates the appliance's temperature and any other settings that have been installed outside. This study focuses on the drying characteristics of a an over ripened banana using two dryers i.e tray dryer and solar dryer. The time and temperature combination for the drying of bananas was optimised.

Keywords: karpooravalli, overripening, nutribars, tray dries, control panel

Introduction
That heated air is constantly being recirculated is the machine's primary functioning concept. Forced conventional heating is used to evaporate moisture from the particles in the trays. The process of drying out the air takes place in stages, yet all at once.

First, the wet solids are deposited onto the trays and transported to the drying chambers. Next, the air is drawn in via the intake and heated by the heaters.

Objective
The objective of the heating is to ensure whether the heated air reaches the wet solids on the trays. Therefore the fans present in the tray are used to circulate the hot air at a speed of two to five meters per second. The turbulent air flow reduces the atmospheric partial vapor pressure and the thickness of the layers of the air boundary.

The heated air picks up the water. During the evaporation of water from the surface, there is a diffusion of the water from the interior of the solids by a capillary action. Also these events happen Ina single pass of air. There is only a short contact time and only a small amount of water is being picked. As a result the discharge air at a rate of 80 to 90% and is circulated back through the fans, only a maximum of 20% of fresh air is introduced.

The moisture discharge occurs through the outlet. Therefore, uniform air flow and constant temperature over the solid materials can be maintained for achieving uniform drying. The materials to be dried are dried until the desired moisture content is attained. By the completion of the drying process, the drying trays are pulled out of the chamber and taken to the tray dumping station.

Advantages and Disadvantages
1. Tray dryers are very useful when the production rate is small
2. In the tray dryers the handling of the materials, loading and unloading of the materials can be done without losses.
3. Energy saving is significant.
4. Tray dryers require more labour to load and unload, hence increases in the cost.
5. They are expensive to operate.
6. Drying by circulation of air across a stationary layer of solids is slow, and drying cycles are long : 3 to 48 hours per batch.

Review of Previous Works
In order to dry a variety of agricultural products, Vinay Narayanan hedge *et al*. (2015) created an indirect, active-type, affordable, environmentally friendly solar drier. The dryer was made with inexpensive, readily available, and biodegradable materials found nearby. The dryer comprises of a drying chamber, a fan with a regulator to create the necessary air flow in the system, and a solar flat plate air heater with three layers of insulation. Because they are nutritious, dried bananas are a necessary part of the diet. The tests involved drying banana slices and examining their drying features, such as rate of drying and dried banana quality in terms of flavor, color, and form. The dryer has two distinct air flow configurations (air flow between the glass cover and absorber plate is known as the top flow, and air flow between the absorber plate and the bottom insulation of the solar collector is known as the bottom flow), forced flow with variable flow rates from 0 to 3 m/s, and two different mounting schemes (conventional trays and wooden skewers).

Xiao *et al*. (2018) found that 27 of the 38 candidate genes were significantly induced during the ripening of banana

fruit, with enzyme activities being regulated at both the transcriptional and translational levels. These candidate genes encode proteins that are involved in the breakdown of starch in bananas. The following is how we evaluated the statistically significant relationship between variety, storage time, and their interaction on starch content: I The amount of starch in each variety varied, with plantains having a lower hydrolysis rate than the other varieties at Day 0; (ii) the amount of starch hydrolyzed during ripening was substantial; and (iii) the progression of starch hydrolysis varied during ripening depending on the variety.

According to Aly and Seleem (2015), extrusion improved the color profile of the composite flour flakes, all of which displayed distinct variances (p 0.05). The 100% millet flakes' lightness value was the lowest (50.09). The composite flakes' L* scores, which ranged from 50.50 to 54.62 but were lower than the highest-ranking raw carrots (57.32), were higher. The (redness) value, on the other hand, varied from 0.76 to 32.20 and varied significantly (p 0.05) across all samples. 100% carrot flour showed a considerably high value of 9.37 when compared to the composite flours, but not as high as redness of raw carrot, while 100% millet flour had the least redness and the values gradually increased as the quantity of carrot flour increased (32.20).

Nitya Sharma and others (2017) Significant amounts of protein, fiber, minerals, and phytochemicals are present in foxtail millet. By employing the right processing techniques, antinutrients like phytic acid and tannin found in this millet can be reduced to undetectable levels. Additionally, the millet is said to have antioxidant, low-glycemic index, and hypolipidemic properties. The use of foxtail millet as a dietary source is still insufficient. However, due to the fact that it can thrive in challenging environments and does not require a lot of agricultural inputs during growth, it is now the subject of increased study and economic interest.

Compound Parabolic Collectors (CPC)

Compound parabolic collectors are the non-imaging concentrators. They have the capability of reflecting to the absorber all of the incident radiation within wide limits and they have the potential to collect solar energy and this was found by Winston in 1974. To reduce the solar orientation the concentrator can be moved by using two sections of a parabola facing each other. The CPCs can accept the incoming radiation using a wide range of angles. With the use of multiple internal reflections, any radiation entering the collector finds its way to the absorber surface located at the bottom of the collector. The absorber may be flat, bifacial, wedge or cylindrical.

Types :Symmetric and Asymmetric

They also have two main types of absorbers they are the fin type and tubular absorbers. For the fin type they can be flat, bifacial or wedge and for the symmetric type they can be single channel or multichannel.

The CPCs should have a gap between the reflector to prevent the heat away from the absorber. This gap may result in the loss of reflector area and loss in the performance so the gap should be kept small. This criteria is more important for the flat receivers. For the higher temperature applications a tracking cpc can be used. This tracking can help in collecting one or more reflections on the parabolic surfaces as they are rough and intermittent. The CPCs can be manufactured either as one unit with one opening and one receiver or as a panel. In asymmetric CPCs they are combined with reverse or upside down absorber plate configuration. By this the heat loss from the absorber is reduced due to the upper side of the plate being well insulated and the convective losses are also reduced due to the convective current being blocked by the plate itself. Compared with the flat plate collector these have lower optical efficiency with the flat plate collector. They have lower optical efficiency due to the scattering losses in the reflector but better efficiency at higher temperature. Recent advancement in the solar based power generating system is the CPCs. This technology is used as a replacement for thermal oil and heating water. The CPCs are a combination of both collectors to collect and concentrate the solar radiations in the diffused form on cloudy days. These collectors are commonly used in the countries having low concentration of solar radiations during winter seasons. The CPC can work upto 160°C and a pressure of 6 bars. The orientation of a CPC is related to its acceptance angle, a 2 dimensional CPC is an ideal concentrator. The collector can be stationary or tracking depending on the collector acceptance angle.Both north–south and east–west directions can be employed with respect to the orientation of its long axis. In both cases its aperture is tilted directly toward the equator at an angle equal to the latitude of the location.

Advantages And Disadvantages

Most radiation within the acceptance angle can transmit through the output aperture into receivers.

Needs good tracking system in order to get maximum efficiency

Experimental Design

Table 1: Combinations Taken.

S. No	Temperature in Celsius	Time in Hours
1	50 C	24,48,72
2	60 C	24,48,72
3	70 C	24,48,72

RSM

Response Surface Methodology which is also known as Response Surface Modeling is a technique meant to optimise the response when two or more quantitative factors are involved. It includes two variables namely dependent and independent variables. Dependent variables are known as responses and independent variables are known as predictor variables. Response Surface Methodology is a very useful tool to optimise factors much more practically compared to statistical significance test for particular point.

Statistical analysis was carried out using design expert version 13.Experimental design and process optimization are two intertwined works. RSM mathematically expresses the relationship between the independent variables, Time and temperature of drying in a quadratic polynomial model, which provides the responses as a function of relevant variables. A central composite design was employed for the present study to obtain the experimental data.

Table 2: shows the various time temperature combinations

Std	Run	Factor 1 A: Time(hrs)	Factor 2 B: Temperature C	Response 1 Moisure content%	Response 2 Yield%
1	2	24	50	1.7	40
2	9	72	50	1	46
3	6	24	70	1.2	45
4	12	72	70	0.3	45
5	10	14.0589	60	2.4	43
6	8	81.9411	60	0.6	44
7	5	48	45.8579	0.8	49
8	4	48	74.1421	0.8	50
9	1	48	60	0.8	50
10	13	48	60	0.8	50
11	7	48	60	0.8	49
12	3	48	60	0.8	50
13	11	48	60	0.8	50

Optimisation

Table 3: shows the ranges of temperature taken

Factor	Name	Level	Low Level	High Level	Std. De.	Coding
A	Time	48	24	72	0	Actual
B	Temperature	60	50	70	0	Actual

Independent variable: 1. Time 2. Temperature

Dependent variable: 1.Moisture content 2.Colour 3.Yield

Moisture Content

Moisture measurement at the beginning and end of drying is essential to follow up the drying course and to decide whether it is achieved or not. On one hand, too long a drying course may have bad consequences for quality and food safety because of unexpected fermentations and mould growth. On the other hand, the next step in the process is storage. The initial and final moisture content of the banana was done. Over ripened banana was cut into slices each weighing 5g and was kept in hot air oven at 100℃. The over ripened banana slices were dried till they reached a constant weight. Similarly the dried banana samples were taken weighing 5g and kept in hot air oven at 100℃.

Addition of corn flour

The banana slices that were kept for drying were turned over the next day. 1% of Corn flour was added to the half dried banana slices in order to absorb the excess moisture from the slices and to make it brittle.

Flowchart

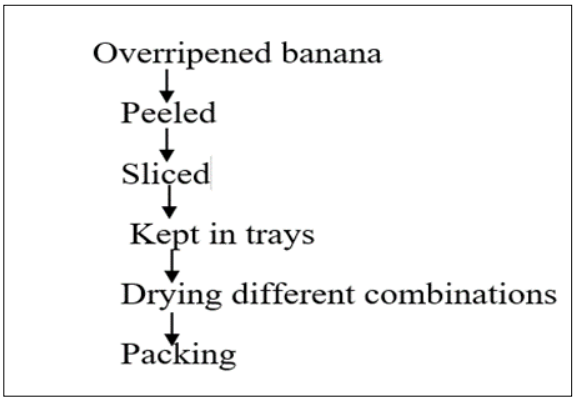

Chart 1

Overripe bananas were purchased. The outer portion was peeled and the bananas were weighed. The weighted bananas were sliced into thin slices using a slicer. The slices were kept in two different trays which were then kept for drying in tray dryer and solar dryer respectively. The weight was taken at regular intervals. The trays were greased with oil before drying. The same procedure was repeated for every combination. The banana slices were then packed and further studies were done.

Nutribar preparation

The banana slices that were dried at 60°C for 48 hrs were cut into thin strips. Foxtail millet was powdered. Banana strips and foxtail millet were taken in three ratios 50:50, 70:30, 80:20. Sugar was measured according to the ratios taken and was caramelised and the ingredients were added to it and mixed. The mixture was spread on a greased plate and allowed to cool to room temperature and then packed.

50:50

70:30

80:20

Fig 1, 2 & 3: Shows ratios of 50:50, 70:30 & 80:20 respectively

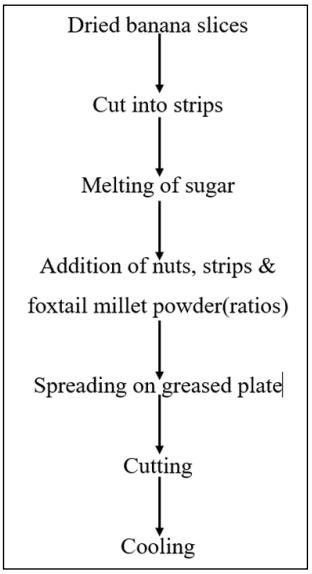

Chart 2

Post drying of banana slices

In order to make the dried banana slices brittle following post drying methods were carried out.

Strips

The dried banana slices were cut into strips and allowed to dry again in dryers

Grinding

The dried banana slices were ground with sugar

Roasting

The dried banana slices were roasted in pan directly to make it brittle

Conclusion

This study focuses on the drying characteristics of a an over ripened banana using two dryers i.e tray dryer and solar dryer. The time and temperature combination for the drying of bananas was optimised. The dried banana was used as a ingredient in making nutribar using foxtail millet.

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