Portable Household Vegetable Dehydrator

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Abstract

Vegetable storage and preservation are issues in many nations, including India. Particularly, certain veggies are safe to consume and fresh during a particular season. Drying is one method of vegetable preservation that has been around for a while. However, sun drying veggies is not feasible due to small kitchens or houses. The goal of this initiative is to find a solution for households. The electric vegetable dryer can be used sparingly and takes up less room. It takes care of the problem of how to store green vegetables, which are best kept fresh and healthy in the winter and go bad even when kept in the refrigerator for three to four days. The project's goal is to enable people to keep veggies at home for their own personal consumption.

Keywords: Design, Development, Dryer, Fruit, Vegetable

INTRODUCTION

One of the greatest post-harvest techniques that has been around for a very long time is vegetable drying. This frees up space for usage, storage, and future consumption. For a drying process to be effective, the food (vegetable) must lose enough moisture to cause a water activity. Insufficient for the growth of microbes. This suggests that sufficient heat transmission is required to supply the latent energy required for vaporization. The majority of people, especially farmers, spread out their crops extensively to allow the sun to dry them before storing them. Regarding veggies, it is crucial to observe the degree of moisture extracted. Excessive drying could compromise the product's nutritional value.

A basic, portable small-scale electric dryer will be a big aid to households in preserving vegetables for extended periods of time. Modern dryers use electricity as their power supply and have a heavy capacity, operate, and maintain. The "Portable Household Vegetable Dryer" project uses power to generate heat and takes up very little room. The goal is to find a solution for the issue of leafy vegetable storage throughout the year. As of right moment, three or four vegetables have been considered. One typical issue is that during the winter months only are green vegetables safe and fresh to consume; during the rainy season, most of these are extremely expensive and not even fresh.Therefore, it will be both economical and healthful to preserve these veggies and use them at a later time. The apparatus is made to address this problem.

Principles of Vegetable Dehydration

Vegetable dehydration, at its core, involves the removal of moisture content from fresh produce, thereby inhibiting the growth of microorganisms that cause spoilage. This process effectively extends the shelf life of vegetables while retaining their essential nutrients, flavors, and textures.

Methodology

Selection of dehydrator

1. **Capacity and Size Requirements**

Volume of Production: Consider the quantity of vegetables to be dehydrated regularly.
Space Availability: Evaluate the available space for the dehydrator in your facility or kitchen.

1. **Energy Efficiency**

Power Consumption: Assess the energy usage of the dehydrator and its impact on operating costs.
Efficient Technology: Look for models with energy-saving features or mechanisms.

2. **Cost Analysis**

Initial Investment Consider the initial purchase cost of the dehydrator.
Operating Costs: Evaluate long-term costs, including maintenance and energy expenses.

3. **Maintenance Considerations**

Ease of Cleaning: Assess how easy it is to clean and maintain the dehydrator.
Durability: Consider the build quality and longevity of the dehydrator.

4. **Drying Time and Efficiency**

Speed of Dehydration: Evaluate the time taken to dehydrate vegetables efficiently.
Consistency of Results: Consider the quality and uniformity of the dried vegetables produced.

5. **Temperature and Humidity Control**

Precision Control: Look for dehydrators with accurate temperature and humidity settings for different vegetables.
Adjustability: Consider whether the dehydrator allows you to customize settings for various vegetables.

6. **Noise and Environmental Impact**

Noise Level: Some dehydrators can be noisy during operation, which might be a consideration depending on the usage environment.
Environmental Impact: Assess if the dehydrator aligns with sustainability goals and has a minimal environmental footprint.

7. **Additional Features and Accessories**

Timer and Controls: Some models offer programmable timers and digital controls for convenience.
Additional Trays or Racks: Consider if the dehydrator allows for expandability to accommodate varying quantities of vegetables.

Design

during design process the size and shape of the prototype was taken into consideration. the main aim is to make it portable as well as aesthetically pleasant. To minimize the space used by the product, it is design to be rectangular and 1 trays are stacked inside it. The machine was evaluated for drying tomatoes with an initial moisture content of 63% (wb). A heating element was attached below the fan of the dryer to allow a through air circulation instead of the cross air flow pattern of the previous design. Thermostat was used to regulate temperature and relative humidity in the drying compartment at 42oC and 11% RH.

1. size : height 285mm
2. Diameter:200mm

3. Weight: 5kg

Components:

1. sytrofoam box

Expanded polystyrene (EPS) foam, commonly referred to as Styrofoam, is an insulating and lightweight substance. Styrofoam is well renowned for having superior insulating qualities. It aids in regulating the box's contents' temperature, whether it be hot or cold.also it is moisture resistance, so This is advantageous in a dehydrator where food drying may cause condensation.

2. Aluminium foil

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Aluminum foil is a very good heat conductor. Aluminum foil can aid in the equal distribution of heat in a dehydrator, facilitating the drying of food. Aluminum foil reflects heat and light due to its high reflectivity. By reflecting heat towards the food in a dehydrator, aluminum foil can help increase the process's efficiency. Since most foods are non-reactive with aluminum foil, it won't add any flavors or odors to the meal that is being cooked or dehydrated. You don't have to worry about a metallic aftertaste when using it with acidic dishes like citrus fruits or tomatoes.

3. 12v power supply

A 12V power source is needed for a dehydrator that is intended to run on 12 volts DC.

4. 12v cpu fan

A 12V power source is needed for a dehydrator that is intended to run on 12 volts DC.
Air is blasted by DC cooling fan fans parallel to the blade axis or along the fan's axis.
To enhance air circulation, position the CPU fan inside the dehydrator. During the dehydration process, this aids in the uniform dispersion of heat and moisture elimination.

5. W1209 thermostat

The thermostat controller W1209 is very inexpensive and quite capable. With this module, you may use the accompanying high precision NTC temperature sensor to sense temperature to intelligently manage power to most sorts of electrical devices. Despite the inbuilt microprocessor in this module, no programming experience is necessary. Three tactile switches let you adjust a number of settings, such as the trigger temperatures that turn on and off. The highest voltage at which the on-board relay can switch is 240V AC at 5A or 14V DC at 10A. Its three-digit, seven-segment display shows the current temperature in degrees Celsius, and an on-board LED indicates the current relay state. Also Temperature Control Range is -50 to 110 C.

6. Bulb

Bulb is use as a heat source in dehydrator.they emit heat and produce infrared radiation, which helps in the dehydration process. For dehydrating, we used bulb with wattages ranging from 40W to 100W.

7. tray

A dehydrator's trays are a necessary part since they offer a surface on which food is placed to dry.

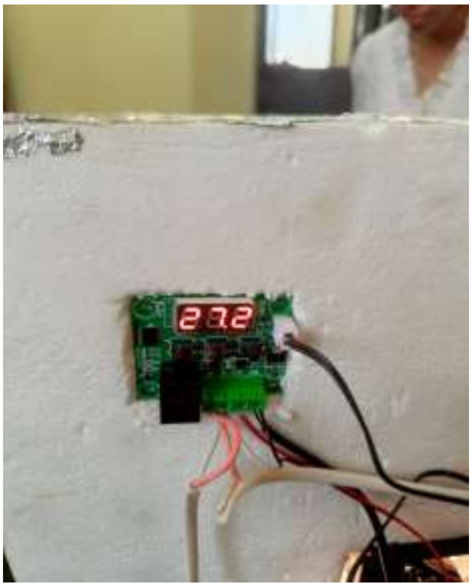
Working

A Styrofoam box is cleverly made into a controlled environment by adding essential components. The principal objective is to build a temperature- and airflow-controlled environment that can be used for incubation or other applications requiring regulated temperatures.

This deliberate activity has two purposes: it acts as a reflecting surface to prevent the Styrofoam from absorbing heat and helps to retain the heat generated inside the box.

Then, a 12V fan is installed on one side of the Styrofoam box. Maintaining the small area's uniform air flow depends on this fan. Proper air circulation is necessary to provide a regular distribution of heat and

prevent the development of hotspots. The fan is positioned to maximize airflow, which increases the overall efficacy of the system.
Secured to the opposite side of the Styrofoam box is a 12V lightbulb. The heat source provided by the lightbulb increases the box's overall temperature. The lightbulb is carefully positioned so that it doesn't come into direct contact with the Styrofoam or anything else that can catch fire inside the box.
The heat generated by the lightbulb and the reflecting properties of the aluminum foil combine to create a controlled temperature environment.
The next step deals with the electrical configuration of the system. The 12V fan and lightbulb are connected to a 12V DC power supply via wires. Preciseness is crucial at this point, and precautions are made to ensure a secure connection while preserving the correct polarity. Good wiring ensures that these components work together when the system is powered on.
Including a thermostat or other temperature control device is one way to give the configuration even more control. This component allows for automatic temperature adjustments based on the internal temperature of the Styrofoam box.
When the power source and the components that need to be regulated are connected to the temperature control system, the precision of temperature regulation increases. The well designed interaction between the components starts as the system is powered on. The fan turns on to facilitate the flow of air as the 12V lightbulb starts to release heat. The reflective aluminum foil lining of the Styrofoam box controls the thermal environment by assisting in the retention of heat generated.
Regular monitoring is required to ensure that the temperature inside the box is within the intended range. On systems with a temperature control component, the thermostat settings can be adjusted as needed.



Calculations

For 1kg tomatoes

(a): Amount of moisture to be removed in is given in Equation

%Moisture = 100 ($M_{INITIAL}$ - M_{DRIED})/$M_{INITIAL}$. ------------------(1)

Initial Moisture Content: 95%

- *Desired Final Moisture Content: 5%
- *Drying Rate:* 0.5 kg/hour (hypothetical rate)

Moisture to be removed = Initial moisture content - Desired final moisture content = 95% - 5% = 90%

Moisture to be removed from 1 kg of tomatoes = 1 kg * 90% = 0.9 kg

let's use the drying rate to calculate the time needed to remove this moisture:

Drying Time = Moisture to be removed / Drying rate

Drying Time = 0.9 kg / 0.5 kg/hour = 1.8 hours

This calculation estimates that it would take approximately 1.8 hours to remove the moisture from 1 kg of tomatoes at a constant drying rate of 0.5 kg/hour.

Quantity of air required to effect drying in kg (Qa). This can be calculated as

Q_a=M/H_{r2}-H_r^1

where MR is as calculated in Eq. (1) and Hr1 and Hr2 are the starting and end humidity ratios in kg/kg dry air, respectively. The average ambient temperature, wet bulb temperature, and relative humidity are 31ºC for dry bulbs, 28ºC for wet bulbs, and 35% for both. With a normal temperature and 101.325 kpa barometric pressure, the psychometric chart yields the initial humidity ratio (Hr1) of 0.01 kg/kg dry air.

Volume of air to effect drying in m3 (Va) can be expressed as

V_a=Q_a/r_a ----------------------------(3)

where r_a is the air density in kg/m3, which is 1.115 kg/m3 at 0 ºC based on typical fluid characteristics. The amount of heat needed to cause drying (hour) in KJ is provided by:

Hr = (M x HK) + (HL x MR) ----------(4)
M=1 kg
HK=2 kJ/kg (The specific heat of tomatoes should be used in place of this arbitrary number.)
Water vaporization's latent heat at ordinary conditions is given by the formula HL=2500 kJ/kg.

Hr=(1×2)+(2500×1)

Hr=2+2500

Hr = 2502

Hr=2502 kJ

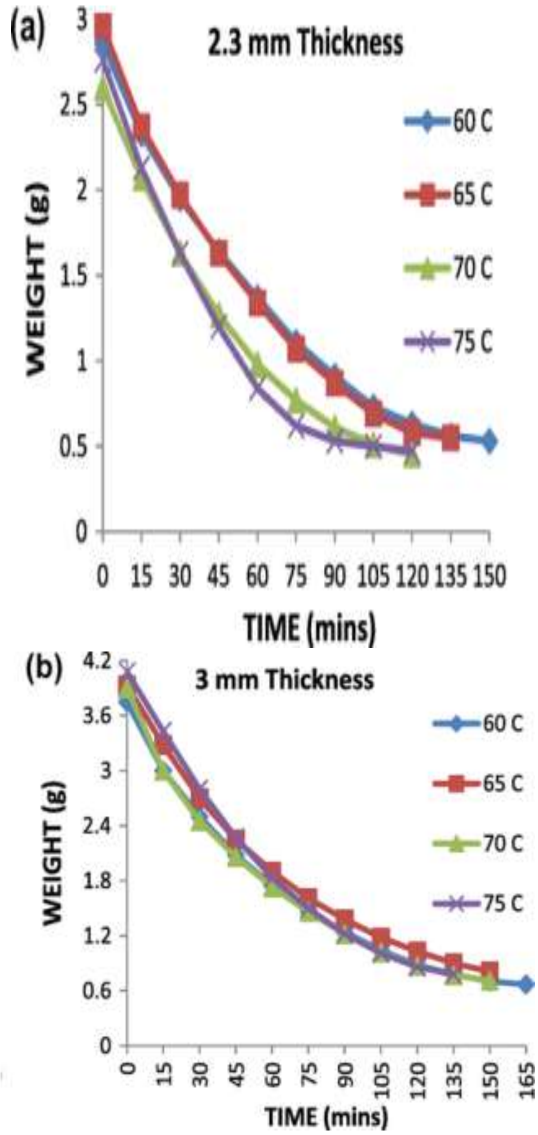
Therefore, 2502 kJ of heat would be needed to effectively dry 1 kilogram of tomatoes, assuming that all of the moisture is gone. It is important to use precise and specific figures for your calculations, as the actual values for specific heat and latent heat may differ depending on the particular variety and condition of tomatoes.

Heat transfer rate (Qht) can be determined as:
$Q_{ht} = hAT_B$ ------------(5)
h = 100 W/(m2·K) (This is an approximate figure; for your particular situation, use the actual heat transfer coefficient.)
A =0.1 m^2. (Assuming the tomatoes have a surface area of 0.1 m²; substitute the real surface area.)
T=20 K (replace "assumed" temperature difference with the actual temperature difference of 20 K)
The precise value of the exponent B would determine how this calculation is done. In the absence of B, it would normally be regarded as 1, and the formula reduces to
$Qht=h \cdot A \cdot T$
Rate of mass transfer The mass transfer rate Q_{mtr} in kg is determined by using
$Q_{mtr} = M_c A_t (H_r^1 – H_r^2)$ x q_2 -------------(6)
Mc=1 kg
At = 0.1 m^2 (Use the actual transfer area in place of the assumed 0.1 m² transfer area.)
Hr1=2502 kJ (substituting the real value for the one assumed in the preceding calculation)
Hr2=0 kJ (because 2Hr2 is zero if the tomatoes are fully dried)
q2 = 1 kg (substituting the actual moisture removed during drying for the assumed total moisture removal).
$Q_{mtr}=1 \cdot 0.1 \cdot (2502-0) \cdot 1$
$Q_{mtr}=250.2$ kg
Therefore, if 100% of the moisture is removed from 1 kilogram of tomatoes, the mass transfer rate would be 250.2 kg. Note that these numbers are based on assumptions about the drying effect's transfer area, initial heat need, and moisture removal during the drying process.
Drying rate: The time required to dry a product from its beginning moisture content (Q1) to its ultimate moisture content (Q2) and the rate at which drying is occurring must be known for calculations regarding the design and analysis of dryers.
$R_c=M_d*(Q_1-Q_2)/A_s*t$ -----------(7)
Md=1 kg
Q1=0.95 (substitute the real number for the initial 95% moisture content assumption.)
Q2=0.05 (substitute the actual value for the assumed ultimate moisture content of 5%).

As=0.1 m2 (Substitute the actual surface area for the assumed 0.1 m^2 drying surface area.) Rc =0.1 kg/(m2·h). (Using the actual drying rate in place of the assumed 0.1 kg/(m^2•h) drying rate.)

t=1·(0.95−0.05)/0.1*0.1
t = 0.9/0.01
t = 90 hr
Therefore, assuming the stated values, it will take 90 hours to dry 1 kilogram of tomatoes from an initial moisture level of 95% to a final moisture content of 5%. Note that the starting and ultimate moisture content, surface area, and drying rate are all assumed in these calculations.

Graphs :



Results:
The primary outcomes that a vegetable dehydrator generates are increased vegetable storage, diversity, and nutritional value. First off, the process extends the shelf life of vegetables significantly by removing

moisture, inhibiting the growth of bacteria, and delaying rotting. Because they weigh less and have a smaller volume, dehydrated vegetables are easier to store and carry.

Furthermore, drying out plants brings out their inherent scents. Concentrated flavorings enhance flavor and contribute to a more noticeable flavor profile when rehydrated or used in cooking. Nutritionally speaking, the procedure preserves a large portion of the vegetables' fiber, minerals, and antioxidants.

Dehydrated vegetables can be added to salad dressings, trail mixes, soups and stews, and quick snacks, among other things. This flexibility meets the demand for readily accessible and practical food options. Reduced food waste can be achieved by preserving excess or seasonal produce with vegetable dehydrators, which are inexpensive and energy-efficient.

Uniform drying is a crucial component of well-designed dehydrators because it prevents parts from being over- or under-dried and ensures consistent quality. Dehydrated vegetables are an excellent option for a range of tasks, such as emergency food supplies or outdoor sports, because they are visually appealing, lightweight, and compact. Longer shelf life, more concentrated flavor, conserved nutrients, and a range of applications are the main advantages of a vegetable dehydrator, all of which promote efficient food preservation and increased culinary possibilities.

Discussion:

The aforementioned results of vegetable dehydration highlight the various benefits of this technique for food preservation. One important advantage that deals with food loss and deterioration is the increased shelf life brought about by moisture reduction. The reduction in weight and volume not only enhances storage and transit logistics but also contributes to sustainability goals by minimizing the need for packaging.

The concentration of flavor found in dried vegetables is evidence of the culinary appeal of this preservation method. Stronger flavor profiles affect both home and industrial food production and make for a more enjoyable eating experience. This outcome demonstrates how tasty dried vegetables may be used as ingredients in a wide range of culinary applications.

The fact that dehydrated vegetables retain valuable nutrients supports their classification as a nutrient-dense food source. The general fiber, mineral, and antioxidant preservation contributes to the final product's nutritional profile, even though some heat-sensitive vitamins may be affected. This is particularly crucial when cooking meals that are balanced and high in nutrients.

The versatility of the dried veggies increases their usefulness in a range of culinary situations. Dehydrated vegetables are versatile and meet modern consumer demands for flexible, portable food options. They can be used as a quick snack or as a robust component in a number of dishes.

The energy and financial efficiency of vegetable dehydrators increase the applicability of this preservation technique. When seasonal goods can be economically preserved, food waste is reduced, and the energy-efficient features meet environmental goals. The discussion is on the flavor, nutrition, flexibility, and sustainability implications of dehydrating vegetables. As technology advances, significant advancements in dehydrator design and operation may provide ever-more intricate and efficient outcomes, hence augmenting the role of dried vegetables in global food provision.

Conclusion

The dehydrator is a versatile and indispensable instrument in the realm of food preservation and creative cooking. Its impact extends beyond practical application; it influences our perspectives on food storage, consumption, and sustainability.

Food preservation is greatly aided by a dehydrator's ability to remove moisture from food, extending its shelf life. By doing this, food waste is decreased and opportunities are created for seasonal products to be sold year-round. The tiny and light designs of modern dehydrators have brought about a significant shift in how people store and consume food. This flexibility is particularly critical in an era where living in urban areas and having a small living space are key determining factors for lifestyle decisions.

Vegetable producers can simply inspect and maintain a fruit and vegetable-drying apparatus that was created and constructed utilizing inexpensive components. The gram weight of the tomato slices being dried is significantly impacted by the size, air flow rate, and drying duration. The tomato's gram weight decreased as the drying time increased for all tomato sizes and air flow rate levels. With an increase in air flow rate, the gram weight fell for all sizes at all drying time levels. Dehydrated foods have significant nutritional benefits.

While some heat-sensitive components may be lost during the dehydration process, dehydrated meals are generally still a good option because they retain important vitamins, minerals, and fiber.The dehydrator has made an incalculable contribution to increasing culinary inventiveness. They can experiment with different flavors and textures when cooking, from creating their own trail mixes and snacks to incorporating dried foods into a range of cuisines.Moreover, the dehydrator aligns with the growing consciousness over sustainability. It promotes eco-friendly eating habits by reducing reliance on single-use packaging and providing an option for preserving excess or seasonal goods.

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