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Traditional and Contemporary Drying Methods an Overview

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ABSTRACT

The most crucial step in every pharmaceutical industry is drying. Drying forms one of the method that is frequently utilized to increase the product stability of biotherapeutics. Basically, drying can be done by two processes viz. natural drying and mechanical drying or artificial drying based on source of energy. Natural drying takes place under the influence of sunlight and wind and is of three types viz. sun, solar and shade drying. In natural drying there is no control over temperature, air flow and humidity whereas in artificial drying, these conditions are well controlled. In case of natural drying, it may be either direct sun-drying or in the shed. If the natural color of the drug (digitalis, clove, senna) and the volatile principles of the drug (peppermint) are to be retained, drying in shed is preferred. If the contents of the drugs are quite stable to the temperature and sunlight, the drugs can be dried directly in sunshine (gum acacia, seeds and fruits). Drying by artificial means includes drying the drugs in an oven; i.e., tray-dryers; vacuum dryers and spray dryers. The pharmaceutical industry uses a variety of drying systems, including fluidized bed drying, freeze-drying, microwave drying and spray drying. Many advantages result from removing water content through the drying process, such as lower transportation costs, easy handling and storage, and increased stability.

Key words: *Ayurvedic, Bhanu Paka, Atapa Suska, Chaya Suska, Pharmaceutical, Drying, Dryers,*

Introduction

Ayurveda is a traditional Indian system of medicine that also deals with pharmaceutical science. In *Ayurveda,* the branch dealing with the preparation of medicines is known as *Rasa shastra* & *Bhaisajya Kalpana*. *Ayurvedic* medical knowledge is dispersed through classical *Ayurvedic* texts. The *Saranghadhara Samhita*, written by *Saranghadhara,* systematically explains and updates the knowledge of preparation of *Ayurvedic* medicine. There are few classical text books which deals with the pharmaceutical preparation of *Ayurvedic* medicines. *Saranghadhara Samhita* is one of them, it deals with the composition of medicines and can be considered the source of *Ayurvedic* pharmaceutical science. It contains three *Khandas* (sections) and some chapters in the first part deal with the basic principles of drug preparation while the second deals with drugs.

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The industrial production of *Ayurvedic* formulations brought with it new challenges such as deviation from the basic concepts of drug production. *Ayurvedic* Pharmaceutical science also has its own basic principles that must be understood and followed in formulation and manufacturing. If the preparation is made without following the basic principles, it can cause complications, because the quality and effectiveness of the medicine depends on it. The demand for *Ayurvedic* products has increased worldwide as synthetic drugs are not safe. Many multinational pharmaceutical companies are now focusing on manufacturing *Ayurvedic* & herbal products.

In the pharmaceutical industry Drying is an important operation. It is important that the remaining moisture is low enough to prevent product damage. The product may contain small amount of water or large amount of water, Drying generally refers to the removal of relatively small amounts of water from a solid material, and the term evaporation is generally limited to the removal of relatively large amounts of water from solutions. In drying processes, the main focus is usually on the solid product. In most cases, drying means removing water below its boiling point, while evaporation means removing water by boiling the solution.

The difference also lies in the fact that during evaporation the water comes out of the material as practically pure water vapor, which has mixed with other gases only due to unavoidable leaks. In drying, on the other hand, water is usually removed by circulating air or another gas over the material to carry away the water vapor. In some cases, drying involves turning the prescribed herbal medicine, such as *Guduchi*, into a free-flowing solid. Drying is also an important step in some formulation operations, especially in the manufacturing of tablets by wet granulation etc. Depending on the type of chemical ingredients you can choose a drying method for the medicine.

Materials and Methods

Drying can be of two types - (1) natural and (2) artificial. Natural drying is done by sunlight and wind and is of three types viz. sun, solar and shade drying or artificial drying based on energy source.

Natural Drying

Drying is an important procedure in pharmaceutical industry. It ensures that the raw product required for manufacturing of drugs is readily available, can be stored and processed without loss of active ingredients. Use of fresh dried drug is advocated in classical texts of Bhaishajya Kalpana like *Sharagdhar Samhita*.

शुष्क नवीनं यद्रव्यं योज्यं सकलकर्मसु ।।[1]

On all occasions the drugs which are dry and fresh should be selected.

Herbal drugs can’t be made readily available at all places and all season and without losing its therapeutic potency. In order to make it readily accessible and in compatible form the importance of drying and further processing cannot be ignored. Similarly, for finished therapeutic products like powder, tablets etc. drying has an important role in maintaining its potency and shelf life, thereby preventing the drugs wastage. In *Sharangdhar Samhita* it is also mentioned that the dried drug can be used for one year i.e. their potency is retained up to that duration.

गुणहीनं भवेद्वर्षादूर्ध्वं तद्रूपमौषधम् ।[2]

Generally, medicinal herbs (raw material) lose their potency after one year if kept as such.

In *Ayurveda* some of the *Guṭika* are advised to make dry with sunlight after their preparation and some of the *Guṭika* are advised to make dry in shade *(Chāyasuşka)* according to specifications mentioned for drying of *Guṭika*, must be followed. Because the drugs which are photosensitive, are advised to dry in shade (*Chāyasuşka*) and drugs which can tolerate sunlight and drugs which can get more potency by exposing to sunlight are advised to dry with sunlight.

Table 1: *Chayasuska* and *Atapasuska* methods mentioned in some *Ayurvedic* formulation.[3,4]

SN	योग	आतप शुष्क / छाया शुष्क
1.	अंकोटा वटक	छाया शुष्क
2.	अभ्र वटिका	आतप शुष्क
3.	अमृतप्रभावटी	छाया शुष्क
4.	इन्दुकला वटिका	छाया शुष्क
5.	उन्मादभञ्जनी गुटीका	छाया शुष्क
6.	नागराद्यो मोदक	छाया शुष्क
7.	प्रभावती वटिका	छाया शुष्क
8.	भद्रमुस्तादी वटिका	छाया शुष्क

9.	भल्लातकहरीतकी	छाया शुष्क

In the classical text *Rasendrasara Sangraha, Lohabhasma* prepared by the procedure called as '*Trividha Lauha Paka.* It is prepared in 3 stages, namely:

1. *Loha Bhanupaka*
2. *Loha Sthalipaka*
3. *Loha Putapaka.*

The three-step processing of *Lauha Bhasma* yields good results, as the iron is process in the first step in *Bhanupaka,* the *Sudhha Loha Curna* is taken in clean suitable vessel along with enough quantity of *Triphala Kwath*. The vessel is placed under hot sun to dry up all the liquid. The process is called as *Bhanupaka* of *Loha Curna.*

The purified iron is washed well frequently with *Triphala* decoction and then kept in a mortar along with *Triphala* decoction and dried in the stark sunlight. This is repeated for 3 to 7 days.[5]

Artificial Drying

Due to high demand of *Ayurvedic* drugs and manufacturing of drugs at large scale pharmaceutical industry has now shifted to various artificial Drying methods that is tray-dryers, vacuum dryers, spray dryers, fluidized bed drying, freeze-drying, microwave drying and spray drying.

Mechanism of the Drying Process

Drying is the act of moving a liquid from a surface into an unsaturated vapor phase. It is attained by applying heat to the material, in order to remove the liquid. The finished product after drying will be a powdered or a dry solid form.

There are two methods for drying out water;

1. **Thermal Process:** Heat is applied during this process.

Two processes are involved in the heat drying process.

a. Heat Transfer: In this process, heat is produced inside the solid and moves outside through the surface.

b. Mass Transfer: This is the process by which moisture is momentarily brought to the solid's surface and then removed through evaporation.

2. **Non-Thermal Process:** It entails extraction, adsorption, and squeezing.

Dryer Types

i. Among the dryers, the dryers used for slurries, suspensions, and diluted solutions are;
   a. Drum drier
   b. Spray dryer
ii. Dryers for moist solid materials are:
   a. Shelf or tray dryers.
   b. Tunnel dryers.
   c. The rotary dryer.
   d. Dryer with fluidized bed.
   e. A vacuum cleaner.
   f. Drying in the freezer.

i.(a) Drum Dryer

Drying viscous, concentrated liquids, slurries, or pastes on revolving drums heated by a stem is a popular application for the drum drier. There are several techniques to apply a thin layer of paste to the surface. Once dry, the dried film is doctored off and collected as flakes instead of powder. Because the drying performance is dependent on the thickness and evenness of the film applied, applicator roll design is crucial. For such a drop to be effective, the paste needs to adhere to the drum's surface. A steel drum with a diameter of 0.75 to 1.5 meters and a length of 2 to 4 meters makes up a drum dryer. The drum is rotated on its longitudinal axis and heated internally using steam. It is possible to regulate the drying pace.

The quantity and arrangement of the steam-heated drums, as well as the atmospheric pressure surrounding the drying sheet, are used to categorize drum dryers.

- Atmospheric Double Drum Dryers
- Atmospheric Single Drum Dryers

ISSN: 2456-3110 REVIEW ARTICLE June 2024

- Atmospheric Twin Drum Dryers
- Enclosed Drum Dryers
- Vacuum Double Drum Dryer

The performance of the drum dryer is influenced by four main factors. They are:

a) Steam pressure or heating medium temperature

b) Speed of rotation,

c) Thickness of film

d) Feed properties

Use:

- Use for suspension, slurries, drying solutions, etc.
- The dried products include yeast, pigment, malt extract, iron salt, zinc oxide suspension, starch product, milk product, antibiotics, and DDT.

Advantages:

- Less time is needed to dry - just a few seconds. Consequently, material that is heat sensitive can be dried.
- The final form of the product has been obtained and is fully dried.

Disadvantages:

- This dryer requires more maintenance than others.
- To regulate feed rats, film thickness, rotational speed, and temperature, skilled operators are necessary.
- Unsuitable for salt solutions with low solubility.

i.(b) Spray Dryer

Only liquid materials, such as solutions, slurries, and thin pastes, are dried using spray dryers.

Application:

There are four parts to the spray drying process;

1. Fluid atomization
2. Droplets are mixed
3. Desiccation
4. Elimination and gathering of the desiccated particles.

Using this technique, the liquid is distributed as tiny droplets into a heated air stream that is flowing, quickly evaporating them before they hit the chamber wall. After drying, the product becomes a fine powder that gathers in a collection system. The processes are finished in a matter of seconds, and the resulting particles range in size from 2 to 500 nm. The spray dryer's maximum size has an hourly capacity of 2000 kg.

Use:

- This product yields a superior form than any other drier
- It can dry a huge amount of material
- It may also be used to dry materials that are hygroscopic, thermolabile, or that are undergoing chemical decomposition.

Advantages:

- The material may be dried quickly.
- There is a high rate of evaporation, preventing droplets from being exposed to extremely high temperatures.
- It is simple to dry the thermolabile materials without causing them to break down.
- The material is dried in a single operation without handling
- The dried powder will have a uniform particle size and shape and may be readily crushed in the form of tablets;
- This dryer is designed for drying under sterile conditions.

Disadvantages:

- The equipment is very expensive and bulky.
- There is a lot of heat waste since the air must still be sufficiently hot when it exits the dryer to prevent moisture condensation.
- Boric acid, methyl cellulose, sulfur, lactose, citric acid, sodium phosphate, milk and food products, soap, and detergents are among the materials that are spray dried.

ISSN: 2456-3110 **REVIEW ARTICLE** June 2024

ii.(a) Shelf or Tray Dryers

Cabinet or compartment dryers are other names for tray or self-dryers. In essence, these dryers are hot air ovens. The number of trays needed depends on the size of the oven and how thinly the material to be dried is spread out on them. By using a mean fan to forcefully circulate a huge volume of heated air, heating is accomplished.

Use:

- A tray dryer can be used to dry sticky materials, plastics, grains, bulk, crystal line material, precipitates, and pastes.
- Drugs, chemicals, tablets, powder, granules, or dry equipment pants are curd.

Advantages:

- Material handling is possible without loss.
- It operates on a batch basis.
- Product value may be managed effectively.

Disadvantage:

- It takes more work to load and unload a tray drier. Cost increases at Heaney
- The procedure takes a long time.

ii.(b) Tunnel Dryer

The tunnel dryer is a device in which the material is either directly put onto a trolley or a container (tray) filled with the material is positioned on the trolley, which is then pushed inside the tunnel chamber door. As the material passes through the drying chamber, it dries. For the tunnel dryer, there are several airflow options, including alternating, vertical, and horizontal airflow, which are chosen based on the drying conditions and material characteristics.

It's a tray dryer modification where a tunnel takes the place of the oven. Food is dried in layers on trays, which are then placed on trucks and driven semi-continuously through an insulated tunnel. The drying chamber is a tunnel that is lined with several carts that hold trays. At one end of the tunnel, the material to be dried is placed, and at the other, the dried material is gathered.

These dryers' air flow may run parallel to the tunnel cart's movement. The term comes from the way it is constructed, which resembles a tunnel. Depending on the technology chosen, a tunnel dryer can finish the drying process while the material is being transferred through the tunnel.

One such source of warmth is

1) hot air circulation
2) Near-infrared
3) Micro wave
4) Radio frequency

Applications:

- Fruits and vegetables are dried.
- The drying of paper and ink.
- Coats drying in the coating line.
- Packing goods being dried.
- Plastic spoons, injectable vials, containers, and caps are dried.
- Powdered and tablet pharmaceuticals are dried.
- Sterilization of packing supplies and containers.
- The process of drying textiles.
- Drying eggs, vegetables, roots, and fresh fruits.
- Food processing and confectionery drying.
- Ceramics in a mold are drying.

Features:

- The tunnel dryers have an advantage over tray dryers in that they may be utilized for large-scale production and operate both continuously and semi-continuously.
- Dry a lot of food in a short amount of time.
- Better product quality, lower labor costs, and high energy efficiency.

ii.(c) Rotary Dryer

A rotary dryer is a modified tunnel dryer with a horizontal tube that is slightly tilted to allow material fed at one end to pass through the tube gradually and towards the other end as the tube rots slowly at a rate of around 10 revolutions per minute.

The "drum," a sizable rotating cylinder positioned horizontally but slightly angled, is the main component of rotary dryers. To get a desired moisture content, material travels through the drum and is heated by a heating medium in accordance with a preset temperature profile and retention (or residence) time.

The exhaust gas handling equipment is positioned at one end of the drum, and a burner is mounted at the other. The stationary input and outflow breechings are connected to the revolving drum using flexible seals.

On trunnion roller assemblies, riding rings, also known as tires, provide support for the drum and enable the unit to rotate smoothly. The drive system, which is usually a gear and pinion arrangement, supplies the force necessary to revolve the drum.

Gravity and the drum shell's rotation help move material along the unit's small downward slope as it is fed into the drum at one end and released at the other.

Applications:

- There aren't many applications that rotary dryers can't handle. They are used in almost every industry due to their extraordinary adaptability. They are frequently employed to process:
- Soil amendments and fertilizers
- Aggregates, minerals, and ores
- limestone and gypsum
- Organic and inorganic chemicals
- Sand
- Roofing granules
- Recycled manure solids (RMS) bedding
- Potash
- Paper pulp and sludge

ii.(d) Fluidized Bed Dryer

To lower the moisture content of raw materials such powder and granules, the pharmaceutical industries frequently utilize fluidized bed dryers. The fluidization of the materials put into the apparatus is part of its functioning principle. Through a perforated bed of moist solid particles, hot air at a high temperature and pressure is injected into the system during this operation. The somewhat moist solids are raised from the bottom and suspended in a stream of air, or in a fluidized state. As soon as the moist solid and hot gasses come into direct contact, heat transfer takes place. The liquid evaporates and is removed by the dry gas. Partially recycled gas occasionally exits the system.

A highly adaptable piece of machinery, the fluid bed dryer is widely used in the pharmaceutical sector to lower the moisture content of raw materials. It has a number of qualities that make it a dependable and effective option for drying procedures. These are the Fluid Bed Dryer's salient characteristics.

a) Fluidization principle

b) Perforated Bowl

c) Turbulent Motion and Effective Drying

d) High Drying Rate

e) Broad Range of Applications

f) Energy Efficiency

g) Compact Design

Principle of operation for a fluid bed dryer:

The fluid bed dryer is made up of a stainless-steel chamber called the bowl that can be removed and is frequently perforated. The air within is brought in through this perforated bottom, and heaters help to raise the temperature of the air inside. After filtering, the hot air is let to flow through the material bed. The system has a feature that allows a fan to be attached. The fan starts the air flow and keeps an eye on its direction. Additionally, the machine's operating temperature and air flow can be adjusted.

Uses:

In the pharmaceutical manufacturing industry, granulation is a common application for fluidized bed dryers. Granulation is a process that dries the substance to the appropriate moisture level, resulting in properly compacted pharmaceutical pellets.

ISSN: 2456-3110 REVIEW ARTICLE June 2024

Synthetic resins have been produced with the use of a fluid bed dryer. Agrochemicals, food, fertilizers, ceramics, and other products can all be made using this equipment.

For materials that need to be dried in the zone of decreasing drying rate, a machine type known as B-FBD is appropriate.

Advantages:

- The material dries very quickly in a fluid bed dryer because of its high drying rate. This feature makes the machine extremely beneficial in producing a high output.
- Particles by themselves dry out rather than the entire bed.
- A product that flows freely is created.

Disadvantages:

- Many organic powders undergo electrostatic changes during fluidization, therefore effective electrical earthing of the drying chamber and the cloth filters is required.
- Too wet granules cling together on drying, so too wet granules should not be utilized.
- A significant number of fines are generated as a result of the fluidized state's turbulence; however, this flaw can be fixed by using the right binders during granulating.

ii.(e) Vaccum Dryer

The vacuum oven is frequently used in pharmaceutical practice for vacuum drying. A vacuum oven is a modified type of vacuum still that is made up of a jacked vessel that is strong enough to bear steam pressure in the jacket and vacuum within the oven.

Principle:

The idea behind vacuum drying is to create a vacuum that lowers the chamber pressure below the water's vapor pressure, forcing the substance to boil. This technique is typically used to dry hygroscopic and heat-sensitive materials. As a result, water evaporates more quickly, hastening the drying process.

- The cavity trays inside the oven enhance the amount of surface area available for heat conduction.
- To lower the pressure, the oven door is fitted with a vacuum pump and secured airtight.
- The enclosed space (about 1.5 meters square) is divided into many pieces by means of 20 hollow shelves that are part of the jacket.
- The materials to be dried are stored on the trays inside the vacuum dryer, and pressure is decreased by means of a vacuum pump.
- These shelves offer more surface area (about 45 to 50 square meters) for heat conduction.
- Metal trays are positioned above the shelves to store the material.
- An airtight seal can be achieved by securely locking the oven door.
- A condenser is positioned between the vacuum pump and the oven to connect them.

Working:

- The material placed on the shelves is dried using the trays in the dryer, and a vacuum pump lowers the pressure to 30 to 60 Kps.
- The conduction mechanism transfers heat as a result of the door closing firmly and steam passing through the jacket area and the shelves.

Use:

- The following materials can be dried with a vacuum dryer:
  - Apply heat to delicate materials to accelerate their breakdown.
  - Material that is hygroscopic and dusty.
- Medicines that include hazardous solvents. These can be divided into sealed receptacles.
  - Food that includes priceless solvents. Through condensation, these are retrieved.
- Pharmaceuticals that must be used as porous final goods.

ISSN: 2456-3110 REVIEW ARTICLE June 2024

- Adjustable desiccants.

Advantages:

- Easy handling of the materials.
- It is possible to employ electrically heated hollow shelves.
- A sizable surface area is offered. As a result, the dryer's body quickly transfers heat, allowing for the completion of drying.
- The dryer has the ability to supply hot water, which aids in the drying process at the appropriate temperature.

Disadvantages:

- Process of the batch kind.
- Ineffectiveness.
- Costlier.
- The expense of labor is excessive.
- Expensive to maintain.
- The risk of overheating as a result of the vacuum.

ii.(f) The Freezing Dryer

Sublimation is a technique used in freeze drying to extract water from liquid materials. Thus, the procedure is often referred to as lyophilization or sublimation drying.

In order to prevent anything from happening, the liquid in this procedure is first frozen to ice and then sublimated at low pressure. Since ice vaporization only happens at the surface, frozen ice is exposed to a lot of surface area, which allows for quick sublimation.

Applications:

There are five steps involved:

- Setting up and antecedent care
- Prefreezing water to make it solid
- First drying (ice sublimation)
- Secondary drying (moisture left behind)
- Stuffing

By first lowering the ambient pressure, the process of freeze-drying enables the frozen water in the material to sublimate straight from the solid phase into the gas phase.

Use:

The following are the most typical uses for it:

- Making dosage forms, like injections
- Making solutions and suspensions.
- Moreover, blood plasma, vitamins, enzymes, hormones, and antibiotics are dried using it.

Advantages:

- It is possible to dry thermolabile material.
- There is less volatile material loss.
- Maintaining sterility is possible.

Disadvantage:

- High equipment and operating costs
- It is a lengthy drying period
- The recommendation that the product only be packaged in a vacuum, with inert gas, or in a container that is resistant to gases in order to prevent oxidation.

Application of Drying in Pharmacy:

- To make granules for capsules and tablets.
- To make powdered extracts, lactose, and dried aluminum hydroxide.
- To reduce the weight and bulk density.
- For easy storage & transportation.
- For easy crushing up of raw medications easier.
- To increase the medications' stability and stop them from deteriorating.

Selection of Dryers

The selection of the dryer, it is very important to note that in practice one must select and specify a drying system which includes pre- drying stages (e.g., mechanical dewatering, evaporation, pre-conditioning of feed by solids back mixing, dilution or palletization and feeding) as well as the post-drying stages of exhaust gas cleaning, product collection, partial

ISSN: 2456-3110 REVIEW ARTICLE June 2024

recirculation of exhausts, cooling of product, coating of product, agglomeration, etc.

As a minimum, the following quantitative information is necessary to arrive at a suitable dryer:

- Dryer throughput; mode of feedstock production (batch/continuous)
- Physical, chemical and biochemical properties of the wet feed as well as desired product specifications; expected variability in feed characteristics
- Upstream and downstream processing operations
- Moisture content of the feed and product
- Drying kinetics; moist solid sorption isotherms
- Quality parameters (physical, chemical, biochemical)
- Safety aspects, e.g., fire hazard and explosion hazards, toxicity
- Value of the product
- Need for automatic control
- Toxicological properties of the product
- Turndown ratio, flexibility in capacity requirements
- Type and cost of fuel, cost of electricity
- Environmental regulations
- Space in plant

Drying of food and biotechnological products require compliance to GMP (Good Manufacturing Practice) and hygienic equipment design and operation. Such materials are exposed to thermal as well as microbiological degradation during drying as well as in storage.

Discussion

As such methods of drying has always been a matter of debate for the superiority of particular drying process. Depending on the raw product and final desired ingredient required one drying method can have advantage over the other. Traditional drying techniques did not had control over temperature, humidity and tear of contamination by bacteria, funguses, dust etc. modern techniques have power to surpass above limitations when it comes to drying of herbal medicinal materials gradient of temperature and degree of humidity has important role. studies on effect of different drying methods. The process of drying involves using heat to remove a little amount of water or another liquid from a substance. A dryer is the apparatus used for drying.

Many studies have been conducted to see the effect of drying on herbs. The drying temperature plays an important role in to preservation of volatile compounds of dried herbs after the drying process. drying Applying high drying temperature commonly leads to the compounds Content. At high drying temperature trichomes may risk rupture which leads to the loss of volatile compounds through evaporation. In addition, high drying temperature could promote the degradation of compounds in the heat-labile essential oil.

Drying has also its effect on the color of the green herbs. The color degradation in dried herbs is provoked by the degradation of pigments such as chlorophyl and anthocyanin. Freeze drying method showed no significant impact >90% preserved) the content of green Chlorophyl derivatives. The most popular drying method, hot air drying has how impact (65-90%, preserved. Sun drying had significant impact on the preservation of green chlorophyl derivatives. (<35% preserved).

Sun or solar drying is the oldest drying method that has been and is still used to dry many types of agricultural products, such as medical plants and aromatic herbs in most tropical or sub-tropical countries (Orphanides, Goulas, and Gekas 2016). Sun drying may not be a suitable drying method for some types of herbs due to lower product quality. Sun drying causes a substantial color and aroma degradation in dried herbs. In basil (*Ocimum basilicum* L.), sun drying caused a greater reduction of essential oil content compared to shade drying and hot- air drying at 40°C (Hassanpouraghdam *et al.* 2010).[6]

The results of physicochemical parameters that is loss on drying, total ash, acid insoluble ash, alcohol soluble

ISSN: 2456-3110 REVIEW ARTICLE June 2024

extractive and water-soluble extractive values of shade dried sample showed lower values when compared with sun dried and oven dried samples. Preliminary phytochemical analysis of all samples revealed the presence of Alkaloids, Glycosides, Flavonoids, Steroids, Triterpenoids, Saponins, Tannins and Carbohydrates. Thin layer chromatogram of the methanolic extract of shade drying sample after derivatization with anisaldehyde sulphuric acid reagent showed nine major spots major spots, whereas sun and oven drying samples showed eight spots. It concluded that shade drying of plant materials are more suitable and is recommended as drying process showed a high potential in improving quantity and quality of medicinal plants. As per one more research in this area conducted on the standardization *Shankhpushpi* leaves in a Comparison between mechanical & natural drying. Mechanical drying was found to be superior which consisted of drying lower tempature (40°C) in terms of color and phenolic contents. This drying of medicinal herbs should be done in mechanical dryers at lower temperature for better's quality products.[7]

Another research methods on different drying of stem bark of T. Arjuna (shade, Sun and Oven drying) have the finding that shade drying is better method. Based on the results of various pioneering research on different medicinal herbs & mechanical drying at Lowes tempature and shade drying are better methods whereas for other various classes of herbal medicines appropriable drying techniques are yet to be finalized Standardized as per on based on ongoing and future researcher.[8] Easy handling, lower labor costs, high thermal efficiency, and decreased bulk density and weight are the primary benefits of drying. Moreover, drying has drawbacks such as increased cost, the development of electric charge, and the possibility of fire and explosion, therefore caution must be used to prevent the dryer's flammability limits. Spray dryers, vacuum dryers, tray dryers, and other equipment were used here. A tray dryer is primarily used to dry sticky materials; it can also be used to dry granular masses or crystalline materials. For drying solutions, suspensions, etc., a drum dryer is utilized. Additionally, the vacuum drier is less expensive than the tray dryer when comparing the two, and the labor and operating expenses are also higher. Sterilized objects can be dried with a spray dryer. However, the spray dryer is quite costly and large. There are three processes that can be carried out using a fluidized bed layer: granulation, drying, and mixing. For drying, a freeze dryer is most frequently utilized.

Conclusion

Drying in pharmaceutical industry forms a crucial step in drug manufacturing, in order to remove moisture and maintain product stability and efficacy. During the ancient time, pharmaceutical drying was carried out through certain classical methods, that includes *Atapa Suska* (drying in sun light), *Chaya Suska* (drying in the shade) drying by the effect of *Agni* etc. One of the challenges, the pharmaceutical industry faced during this period was mainly regarding the product stability. As there were no advanced techniques during that period to determine or to control the temperature, time etc., it always arises question in relation to drug stability, its efficacy etc. To overcome these queries, pharmaceutical industry is enriched with different types of drying methods with well-established equipment in order to control the temperature, time etc. It is inevitable to avoid or to eliminate moisture which may lead to corrosion and decrease the product or drug stability and to improve or keep the good property of a material. The knowledge of classical and modern methods of drying is giving a new way for research, so that in further studies we can go for a comparative efficacy determination of the drugs dried by both classical and advanced techniques.

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