



Review Article

INSTRUMENTS AND EQUIPMENT USED IN THE PREPARATION OF TRADITIONAL AYURVEDA MEDICINES WITH SPECIAL REFERENCE TO AYURVEDIC TABLET PRODUCTION

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ABSTRACT

Ayurveda a branch of the Indian traditional system of medicines has evolved significantly over the years from conventional manual hand-made tablets or formulations to a more provocative and mechanized process, mainly in the place of tablet production. Tablets are generally the most used dosage forms in Ayurveda due to their comfort in administration, improved shelf life, and greater efficacy. SOPs have to be followed while manufacturing of Ayurvedic tablets which ensures the good quality of medicine. While the cornerstone principles of Ayurveda pharmaceutics remain persistent in classical texts, the incorporation of modern pharmaceutical instruments has magnified the production, safety, quality control, and consistency of these formulations. In former times Ayurveda practitioners would manually prepare tablets using simple equipment like *Khalva yantra*, stone grinders, and hand-rolling techniques. These methods are however effective for small batches but lack compactness in dosage, hardness, and stability, which are essential for large-scale production and therapeutic credibility. The article places these traditional tools with a modern GMP framework, and in-depth examination of essential instruments and equipment involved in the production of Ayurvedic tablets. A well-maintained framework that comprehensively governs every stage of production is important to safeguard both integrity and safety of Ayurvedic products.

INTRODUCTION

Ayurveda the ancient science of life has a well-endowed tradition of formulating medicinal preparations from natural sources such as herbs, metals, and minerals. Among them, *Vati/Gutika* enwrap solitary place due to their convenience of use and its therapeutic potential. Over the centuries, Ayurveda has used a variety of technical tools, which range from simple handheld like *Khalva Yantra* to complex setups like *Putra* for processing metals and minerals. As Ayurveda pharmaceutics unfolded, so did the instruments, gradually integrating modern machinery for large-scale production and standardized

particularly in tablet production. The classical texts of Ayurveda describe in detail the theoretical principles of medicine preparation, but the practical side-particularly the instruments and equipments used constantly remain dispersed and underhanded.

This article concentrates on systematically digging into Instruments and equipment that are used in the production of tablets. It bridges classical methods with modern counterparts used in Ayurveda industries. By doing this, it highlights not only the technical evolution but also the applicability of maintaining traditional certifiable among modern mechanization. Understanding these Instruments and their conversion is vital not just for pharmaceutical scholars, but also for Ayurveda scholars for maintaining scientific upgradations.

MATERIAL AND METHODS

This research work is descriptive and mainly focuses on the identification, and description of

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various instruments and equipment currently used in the preparation of Ayurveda medicines, with particular accentuate on tablet production unit. This will help upcoming generation for pursuing carrier in Ayurveda pharmaceutical industry.

The present research work is split into two parts pre-formulation study and a formulation study, which include raw material identification to the final product till packaging.

Pre-formulation study

Raw material identification/authentication

Identification of raw material is the establishment of final product quality and safety. It reforms the correct drug used for the preparation as mentioned in classical texts. Prevents adulteration and

substitution of various drugs in trade markets, proper identification avoids these failures. It is also mandatory under Ayurvedic Pharmacopoeia of India (API), Good Manufacturing Practices (GMP), and WHO regulatory guidelines. It ensures batch-to-batch consistency uniform action, taste, and dosage of the finished product, especially in tablet production, any irregularity in the tablet leads to the failure of the whole batch produced. Some instruments are being used in the identification of raw material described in Table 1. Raw drug identification is done via pharmacognostic^[1] methods which primarily include microscopic and macroscopic examinations along with other physiochemical and fluorescence analyses.

Table 1: Parameters used for the identification of raw material

S.No.	Parameter	Aim	Instrument/equipment
1.	Organoleptic evaluation	Color, odor, taste, and texture	Human sensor analysis and trained experts
2.	Macroscopic	Morphological and preliminary examination	Magnifying glass, graduated ruler, etc.
3.	Microscopic	Cellular structures and tissues	Microscopes etc.
4.	Physio-chemical tests	Moisture, ash values, and extractives	Loss on Drying apparatus & muffle furnace, muffle furnace
5.	Foreign matter	Detection of unwanted material	Sieves and visual inspections
6.	Heavy metal	Safety for mineral-containing formulations	AAS, ICP-MS, etc.
7.	Microbial load	Microbial safety	Autoclave, incubator, laminar airflow, etc.
8.	Fluorescence	Authentication	UV cabinet, fluorescence microscope
9.	DNA Barcoding	Species identification	PCR machine
10.	Particle size	Determination of particle size	Sieve shakers and sieves

Raw material conversion

Crude raw drugs are often conflicting, unsuitable for direct use, and are impure. Raw material conversion pertains to the transformation of these crude drugs into the pharmaceutically acceptable form for the further production of the formulation. It is a preliminary step in the manufacturing of tablets or other dosage forms. This process ensures that the raw materials are effective safe to use, and standardized for further processing.

Particle size reduction^[2] can be achieved by different methods such as impact, cutting, compression, and attrition/rubbing.

Table 2: Classification of particle size reduction instruments

S.No.	Principle	Instrument
1.	Impact	Hammer mill
2.	Cutting	Knife cutters, dicers, and slitters
3.	Compression	Jaw crushers and crushing rolls
4.	Attrition/rubbing	Mortar pestles, end runner mill, pulverizer etc
5.	Trituration	Mechanical motor pestle, sand grinder, ball mill, etc

Pulverizer^[3]

A mechanical device is usually used in Ayurvedic pharmacies for grinding different types of material. Pulverization is achieved by an impact grinding chamber. It is an ideal unit for grinding non-abrasive soft medium and hard minerals. With the increase in demand for powder for the formulations as well as constantly expanding quality with regards to flow ability, bulk density, particle size distribution, and grain structure the pulverizer is the best for all.

Table 3: Types of pulverizers

S.no.	Name	Working
1.	Hammer pulverizer	Materials are broken by the impact of their own and the high speed of rotary hammer fixed to line material.
2.	Cone pulverizer	Material is broken by squeezing and bending by eccentric rotation within the cone.
3.	Impact pulverizer	Material is broken by impact crushing due to high-speed movement and high-speed collision of the hammer below.
4.	Roll pulverizer	Material falls in between two parallel and opposite cycles of inter roller causing the material to break between the surfaces by friction.

Sieves^[4]

Is used for the separation of particle size as the size range is important in the Ayurvedic pharmaceutical industry as different preparation requires different sizes of drug material. Sieving is a process by which different grades of powders are separated from each other. It is the most commonly used technique of sizing through several screens. Mechanical sieving devices are usually based on methods that agitate or brush the sieve or centrifugal force.

Table 4: Methods of sieves

S.No	Methods	Working
1.	Agitation	Sieves agitated in several ways: <ul style="list-style-type: none"> • Oscillation: sieve mounted in a frame that oscillates back and forth. • Vibration: the mesh is vibrated at high speed. • Gyration: The sieve is given rotary movement of small amplitude of considerable quantity.
2.	Brushing	Can be used to move particles on the surface of the sieve and keep the mesh clear.
3.	Centrifugal	It normally uses a vertical cylindrical sieve with a high-speed rotor inside the cylinder, so that particles are thrown outwards by centrifugal force.

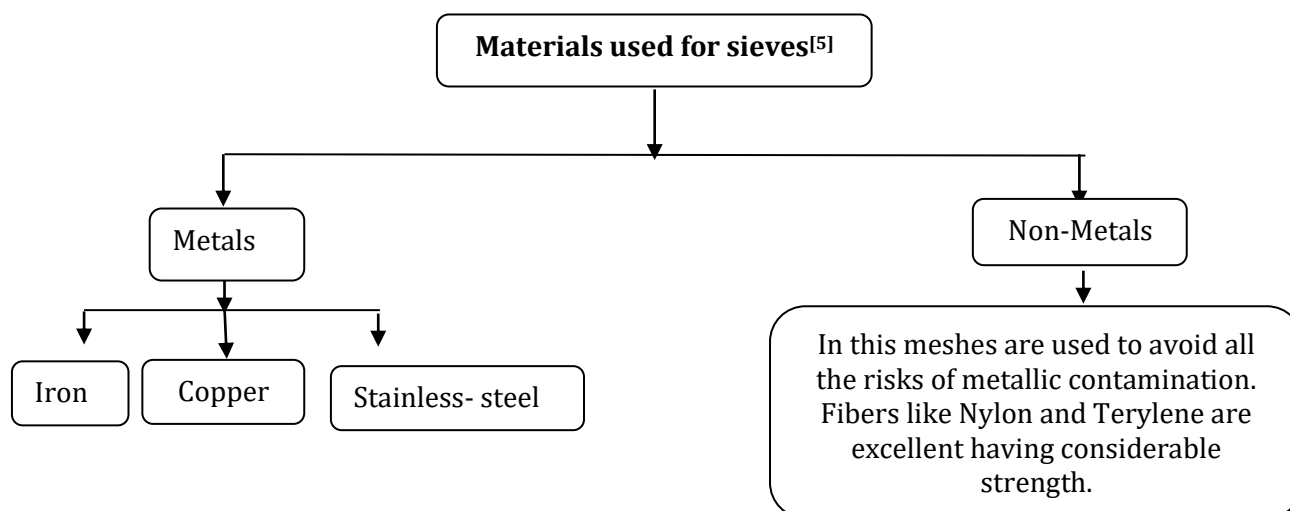


Table 5: Instruments used in size separation

S. No.	Name
1.	Vibrating sieve
2.	Rectangle type sieving
3.	Rotatory type
4.	Granulating sieve
5.	Gravity separation
6.	Cyclone separator
7.	Froth flotation
8.	Electrostatic separation
9.	Magnetic separation
10.	Membrane separation

Moisture content analysis is an essential part of medicine preparation to ensure stability, and shelf life and prevent microbial load. Excess moisture can lead to various contamination, spoilage, and decreased therapeutic value hence it must be done before going further procedures.

Instruments and equipment used

1. Hot air oven (Loss on drying): Samples are weighed and dried at a specific temperature (105°C) for a certain duration, then reweighed until constant weight is achieved. The loss in weight will represent moisture content.

Uses: Drying of herbal raw material at a controlled temperature and the best way to sterilize tools, including plates tubes, and packaging material.

2. Karl Fischer titrator: A chemical reagent named Karl Fischer reagent to accurately measure the water content in any drug even at low levels.

Uses: Used for accurate moisture analysis, specifically in hygroscopic and sensitive substances.

3. Halogen moisture analyzer: It uses halogen heating fused with the analytical balance. Having higher accuracy than the traditional oven.

Uses: Rapid and efficient.

4. Infrared moisture balance: It utilizes infrared radiation to heat the sample and evaporate the

moisture while measuring weight loss for the same.

Uses: Suitable for quick routine analysis in Ayurveda pharmacies.

5. Desiccators with desiccant: these are sealable enclosures containing desiccants used for preserving moisture-sensitive drugs or any raw material.

Uses: it is peripheral equipment for sample handling and preservation.

Formulation of tablet^[6]

Tablets are an important preparation that is mentioned in ancient Ayurvedic texts. Classified according to shape and size, but nowadays a compressed form of this formulation is conventional and is rapidly replacing ancient handmade *Vatis*. The use of additives is now an integral part of the manufacturing of tablets.

The formulation part mainly begins with three essential aspects which are the Master formula, Batch formula, and equipment used.

1. Master formula record^[7]: It acts as a uniform recipe for creating preparation with precise details of each component required for the manufacture of tablets including their botanical names and their pharmaceutical roles. It deals with uniformity and aids in upholding quality standards.

Table 6: Components of MFR

S.No.	Components
1.	Product name (classical/propriety)
2.	Dosage form (tablet, <i>Vati</i> , <i>Gutika</i>)
3.	Therapeutic category (<i>Rasayana</i> or any other)
4.	Reference (if, classical mention text)
5.	Batch size (total no. of tablets to be produced)

6.	Composition (ingredient list)
7.	Manufacturing procedure (SOP)
8.	In process control (size, moisture, uniformity, etc)
9.	Packing details (type, labeling, and batch coding)
10.	Storage
11.	Finished product specifications (organoleptic characters, weight, and other analysis)
12.	Signature and authorization

2. Batch formula: In Ayurvedic pharmaceutical production batch formula is essential for conversion to standard raw material into practical working quantity required for large-scale industry. It is the quantitative expression of the master formula which is calculated based on the desired quantity of tablets to be produced in a specific batch. It contains the total quantity of each raw material required for the particular batch.

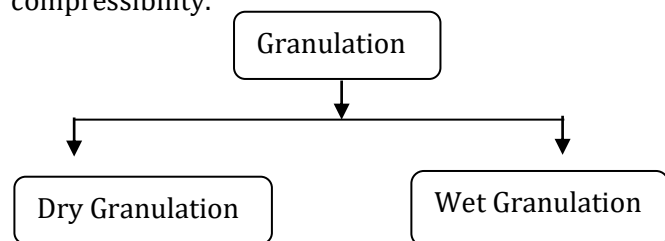
The master formula defines the composition for each tablet, while the batch formula adapts it for large-scale production, serving as a crucial resource for manufacturing personnel to ensure efficiency and consistency.

Table 7: Components of batch size

S.No.	Components
1.	Name of product
2.	Dosage form (tablet/ <i>Vati</i>)
3.	Batch size (e.g. 5000 tablets or 10,000 tablets)
4.	List of ingredients (herbal powders, mineral or metallic, and excipients)
5.	Total quantity required

3. Equipments^[8]

Granulation is the most important unit operation in the pharmaceutical oral dosage forms. These are often required to amend the flow of powder mixtures and the mechanical properties of tablets. Powders/granules intended for compression into tablets must possess two properties that are flow property and compressibility. Flow is required to produce tablets of a consistent weight and uniform strength. Compressibility is required to form a stable and intact compact mass. Granules formed should possess acceptable flow properties and compressibility.



a. Dry granulation equipment

- i) Ribbon blender
- ii) Double cone blender

Ribbon blender

It is most commonly referred to as a horizontal ribbon mixer, which is widely used in industries for the efficient mixing of dry powders, granules, and semi-wet materials. This equipment derives its name from ribbon-shaped blades that perform mixing operations.

The equipment consists of U- shaped horizontal trough, inside helical ribbon blades are mounted on a central rotating shaft. The shaft is powered by an external motor connected through a gearbox to ensure smooth and stable rotation. The mixing time typically varies from a few minutes to an hour, depending upon the nature, particle size, and flow properties of the material being mixed.

These mixers are available in a wide range of capacities, from small laboratory models to large industrial units.

Working principle: Works on two mixing principles

- i) **Convective mixing** is when a large slug of material is moved from one place to another inside the blender (macro movement).
- ii) **Diffusive mixing** is when small particles slide past each other when ribbon blades push forward.

Uses:

It is used to blend large quantities of drugs, dry and wet material.

Results: frequent movement in two directions ensures thorough, homogeneous mixing of powder/ granules.

Double cone blender

It is an essential component of mixing equipment used in the pharmaceutical sector. Its main purpose is to combine dry powder and granular materials gently and uniformly. Its characteristic double-cone shape guarantees efficient material

mixing and tumbling due to gravity. Its moderate rotation makes it perfect for mixing delicate materials since it blends uniformly without degrading them or reducing particle size. It is a cost-effective alternative for batch-mixing activities and is simple to use.

Dry blending of free solids is the most frequent application of double-cone blenders. These blenders can blend solids of different bulk densities and percentages in different ratios.

Working principle

This contains a vacuum intake system or manual feeding to feed the material in containers. Due to continuous rotation, the material is frequently moved in a complex and forceful manner to ensure proper mixing. Both ends are conical, promoting uniform mixing and making discharge easier. However, the speed at which it rotates affects the mixing of material.

Uses:

- i) Wet powder to dry powder mixing can be done with this equipment.
- ii) Stainless steel mixing barrel and blades always keep clean and away from dirt.
- iii) Depending on the product, paddle-type baffles can be provided on the shaft for better mixing.

b. Wet granulation equipments^[10]

- i) Planetary mixer
- ii) Drying – tray dryer and fluid bed dryer
- iii) Comminuting mill (Resizing of granules)

Planetary mixer

These mixers are used for mixing and beating viscous and pasty materials, the planetary mixer is still used for basic operations of mixing and blending in the pharma industry. It works at varying speeds. A double planetary mixer is recommended where product viscosity continues to build up and adequate flow cannot be maintained.

Working principle

The double planetary mixer includes two blades that rotate at their axis while revolving around the center of the mixing bowl. Blades sweep the walls of the vessel to remove material stuck in between and push it towards the center. Continuous movement ensures all material is mixed thoroughly. Thick sticky and viscous materials can be efficiently mixed.

Advantages:

- i) Easy to clean.
- ii) Less concern for cross-contamination
- iii) Easy to discharge
- iv) Low cost
- v) Energy saving is comparatively high.

Tray dryer

Drying is the oldest, most common, and most diverse operation of pharmaceutical applications. It is an enclosed chamber in which trays are placed on top of each other in trolleys. It is used where heating and dryers are essential parts of the manufacturing process in industries. In this, a highly effective recirculating air system is provided. The heated air is recirculated with fresh air in selected proportions for optimum drying. A digital temperature controller with a digital timer is supplied to facilitate working day and night.

Turbo tray dryers are usually suitable for granular feeding material. They operate with rotating shelves and forced convection of the air above the shelves. The product layer is fed onto the first layer, leveled by the set of stationary blades. The dryer can have up to 30 layers or more and provide large residence times.

Vacuum tray dryer is mainly for drying high-grade, temperature and oxygen-sensitive products. Highly suitable for drying hygroscopic substances, this is dried to a very low residual moisture content level.

Uses: Used for drying herbal raw material, pharmaceutical powders, pastes, and triturated Bhasma.

Fluid bed dryer

Small bed dryers are commonly used in the pharmaceutical industry. Aims to better air-solid contact, drying in fluid beds is faster than in ovens due to good mixing product uniformity is much improved. These bed dryers are found throughout all industries. They provide an effective method of drying relatively free-flowing particles with reasonably narrow particle size distribution. In this machine temperature distribution throughout the product is uniform and the heat transfer rate is also high.

Uses:

- i) Heat transfer is quick and efficient because each particle comes in direct contact with hot air.
- ii) Filters prevent fine particles from escaping.
- iii) It is suitable for heat-sensitive materials because low temperatures can be used for a short time.
- iv) Lump formation and case hardening are minimized due to the constant movement of material.

Comminuting mill: It is used for dry and wet granulation, pulverization, or dispersion of products or ingredients in pharmaceutical, and chemical bulk drugs. It consists of a stainless-steel hopper through which the product slides into an enclosed chamber, where it is milled between beaters reduced to the required size and finally collected in a container. The

quality and output depend on the shape and size of the beater.

Multi mill: it is a machine that is used for high-speed granulating, pulverizing, mixing, shredding, and chopping of different types of dry and wet raw material. It works without needing special attachments. It operates on the principle of variable force using swing-type beaters. These beaters have both knife and impact edges, rotating inside a chamber.

c. Blenders with lubrication

Lubricants are added during tablet manufacturing to reduce the friction between the tablet and the metal surface of the die. This makes it easier for the tablet to be ejected from the machine smoothly, helping to prevent cracks, breakage, or sticking. Blenders play an important role when mixing lubricants with powdered ingredients during tablet production. Their main purpose is to ensure the even distribution of the lubricant throughout the powder mixture.

The double-cone blender is widely used in Ayurvedic industries for uniform mixing. It consists of two conical shapes joined together, allowing free flow and tumbling of material inside. It works on the tumbling principle, in which rotating motion causes the powders to repeatedly fall, spread, and fold over themselves. This ensures the homogeneous mixing of components without the use of high-shear blades, making it ideal for fragile herbal powders and lubricants in tablet production.

Uses:

- i) Uniform and gentle blending.
- ii) Closed system which reduces contamination.

d. Tablet Compression^[12]

After the preparation of granules or mixing of ingredients, they are compressed to get the final product. The compression is done either by a single punch machine or a multi-station machine. The tablet press is a high-speed mechanical device. It squeezes the ingredients into the required tablet shape with extreme precision.

Stages occurring during compression

Stage 1: The lower punch stays down, allowing the powder to flow into the die cavity from a feed mechanism.

Stage 2: The lower punch rises slightly to adjust the volume of powder, ensuring the right amount for tablet formation.

Stage 3: The upper punch descends with pressure, compressing the powder inside the die to form a solid tablet.

Stage 4: The upper punch lifts and lower punches move up to eject the compressed tablet out of the die cavity onto the surface plate.

Stage 5: The system resets, and the process starts over for the next tablet.

Machines used

Single rotary tableting: A single-sided rotary press consists of a die table producing a single tablet per station for each revolution. It has the competency to develop a variety of tablets for pharmaceuticals. In tablet production, two punches and a die work together to form a cavity where the powder is filled. The upper and lower punch then compresses the powder with high pressure to form solid tablets.

There are two types of tablet compression machines:

1) Single punch tablet press:

- Uses one set of punches and one die.
- Suitable for small-scale production.
- Simple operation, ideal for trial batch.

2) Rotary tablet press:

- Contains multiple sets of punches and dies arranged on a rotating turret.
- Designed for large-scale batches.
- As the turret rotates, tablets are continuously compressed at high speeds.

Packing: Tablet packing machines play a crucial role in the pharmaceutical industry by ensuring that tablets are packaged efficiently, securely, and by regulatory standards. Depending on the specific packaging needs, these machines are available in different types, which include blister packing machines, strip packing machines, and pouch packing machines. Each type of machine is designed to maintain product integrity, which also enhances shelf life, and supports safe handling during distribution.

- **Blister packing:** These are used to package tablets in blister packs, which consist of a pre-formed plastic cavity and a foil or paper backing.

Working: the tablet is placed in the blister cavity, and the blister is sealed with foil or paper by pressure or heat.

Types: Cold forming and heat-sealing blister packaging.

Advantages: High production speed, good for single dose packing, and has a protective barrier from moisture and light.

- **Strip packing:** These machines are used for packing tablets in strips, required for smaller doses or individual tablets.

Working: The tablet is enclosed between two layers of film that are sealed together by heat or pressure to form a strip.

Types: Cold-sealed and heat-sealed strip packing

Advantages: Ideal for small batches, easy to handle and store

- **Pouch packing:** Used to package tablets in small pouches or sachets.

Working: Tablets are placed into a preformed or heat-sealed pouch, typically in smaller quantities for retail packaging.

Types: Form fill seal pouch and premade pouch filling machines

Advantages: high versatility in packaging, suitable for small to medium-sized packing, and ideal for retail consumer-sized packing.

- **Final packing:** The final stage in tablet manufacturing involves the careful packaging and preparation of products for distribution. This is a very crucial step from physical damage, environmental exposure, contamination, and compliance with regulatory standards.

Table 8: Components of packaging

S.No.	Stage	Description	Equipment
1.	Primary packaging	Tablets are already packed into strips, pouches, or blister packs	i) Blister packing machine ii) Strip packing machine iii) Pouch packing machine
2.	Secondary packaging	Cartoning: Primary packs are kept into cartons along with product description. Cartons are sealed, coded, and inspected.	i) Horizontal/vertical cartoning ii) Laser printer iii) Leaflet inserting machine iv) Inspection system
3.	Tertiary packaging	Shipper boxing: Multiple cartons are grouped and packed into larger shipper boxes for transport and storage.	i) Case erector ii) Case packer iii) Case sealer iv) Labeling machine
4.	Quality assurance	Continuous process checks: weight checks, visual inspection, barcode verification	i) Weight checkers ii) Barcode scanner

DISCUSSION

The manufacturing of Ayurvedic tablets has progressed from outdated handmade processes to modern, machine-based technologies. This shift has helped to overcome numerous difficulties associated with traditional techniques, such as uneven quality, sanitary issues, and difficulty in producing significant batches. However, while technology has greatly supported, it is equally essential to retain traditional Ayurvedic processes and expertise throughout manufacture. This research thoroughly examined the variety of equipment and instruments used in the production of traditional Ayurvedic medications. It revealed that particularly within the pharmaceutical sector, the manual, traditional methods of producing tablets were systematically replaced by semi-automated and fully mechanized processes.

Starting from raw material to final packaging the combination of traditional knowledge with modern machinery has not only retained authenticity but also improved scalability, hygiene, and quality assurance. The use of Good Manufacturing Practices (GMP) compliant equipment has become common in commercial Ayurvedic tablet production units.

Ayurvedic tablet manufacturing grows by combining old and contemporary processes. In the future, there will be a need for Ayurvedic-specific machinery, improved training for those working in this industry, and more environmentally responsible solutions.

CONCLUSION

In summary, modern instruments and equipment have greatly enhanced Ayurvedic tablet manufacturing while maintaining its original persona. A wide range of specialized instruments and machinery are utilized in the production of ancient Ayurvedic medications, particularly Ayurvedic tablets, demonstrating the complex and comprehensive traits of Ayurvedic traditions. These instruments are crucial for precisely mixing herbal components while preserving and enhancing their therapeutic qualities through meticulous processing. It is crucial to acknowledge the significance of the correct instruments in maintaining the true nature and efficacy of these traditional therapeutic techniques while Ayurveda adjusts to modern techniques. Furthermore, these techniques could be enhanced by

future technology advancements, expanding access to Ayurvedic remedies without sacrificing their traditional foundations.

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