Maceration, Percolation and Infusion Techniques of Extraction of Medicinal and Aromatic Plants (MAPs)

J Singh

Central Institute of Medicinal and Aromatic Plants (CIMAP)
Lucknow (India)

E-mail: jsingh@cimap.res.in

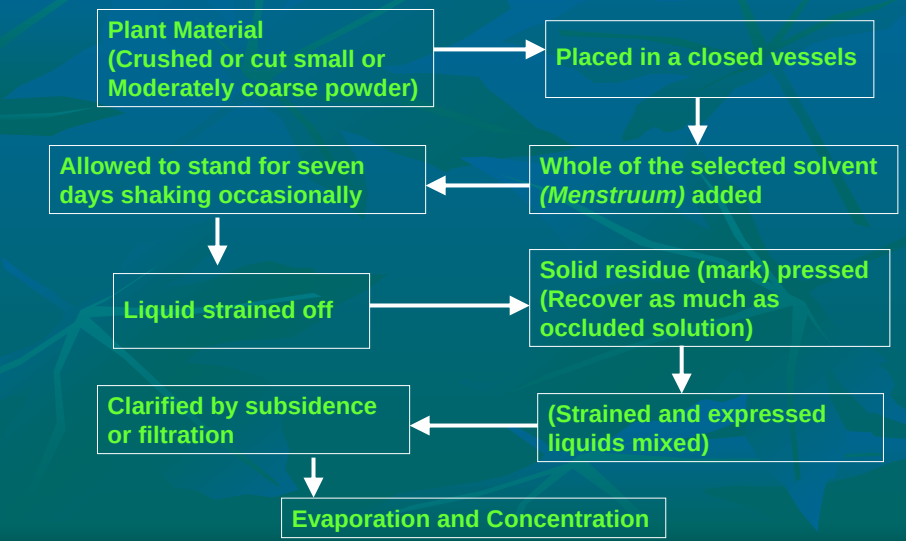
Introduction

- Although, the various classes of preparations involving simple expression, aqueous hot and cold extraction and evaporation were in vogue since long time but, real and scientific rapid progress in the extraction procedures for medicinal plant's preparations was made after 19th century.
- Such extraction techniques and processes were highly successful in the phytochemical field leading to isolation of single pure molecules and standardized extracts for therapeutic purposes.
- Simple traditional to advanced technologies conforming to official procedures are being used to manufacture different types of preparations popularly known as ***Galenicals***. Such class of preparations includes:
  - **Decoctions**
  - **Infusions**
  - **Fluid extracts tinctures**
  - **Semi solid extracts**
  - **Powdered extracts.**

Maceration, Percolation and Infusion Techniques of Extraction: A General Consideration

- These are the general techniques and mostly applied for ***Galenical preparations.***
- **The sole purpose of such basic extraction procedures for crude drugs are to obtained the therapeutically desirable portion and eliminate the inert material by treatment with a selective solvent known as the *Menstruum.***
- Such types of extraction procedures also play a decisive role for the qualitative and quantitative composition of the extracts.
- The standardized extracts, thus obtained are further processed for inclusion in other dosage forms such as Tablets and Capsules containing several groups of plant's metabolites.
- These extracts are also utilized for isolation and characterization of therapeutically active chemical constituents used in modern medicines.

1. Maceration Processes
(Steady – State Extraction)
1.1: General Procedure



1.2: Maceration Processes for Organized and Unorganized Drugs

The processes of maceration for organized and unorganized drugs are slightly differ as indicated below:

Processes for Organized Drugs (*e.g.* Barks, Roots)	**Processes for Unorganized Drugs** (*e.g.* Gum- resin)
Process	**Process**
(i) Drug + whole of ***menstruum***	(i) Drug + 4/5ths (in most cases) of ***menstruum***
(ii) Shake occasionally during 7 days	(ii) Shake occasionally during 2 to 7 days as specified
(iii) Strain of liquid, and press the marc	(iii) Decant the liquid. **Marc is not pressed**
(iv) Mix the liquid, clarify by subsidence for filtration **Filtrate is not adjusted to volume**	(iv) **Filter the liquid and pass more *menstruum* through filter to volume**

Hence	***Hence***
(a) The direction to press the marc because there is a considerable proportion of liquid adherent to it which could not otherwise be separated.	(a) The omission of directions to press the marc because it is neither practicable nor necessary.
(b) The omission of directions to adjust to volume because a variable amount of liquid is left in the mark. This liquid contains soluble matter. If adjustment to volume were made, a weak product would result from defective expression. **Omitting adjustment, the volume of liquid expressed influences the yield of product, but not its strength.**	(b) The direction to adjust to volume because the clear upper layer. (i) Is easily separable by filtration from the lower. (ii) Contains practically all the soluble matter of the drug, the small amount adherent to the gummy matter being washed therefrom the ***menstruum*** passed through the filter. **Hence adjustment to volume leads to uniformity.**
Preparations made by this process -	**Preparations made by this process –**
Vinegar of squill, B.P.C Oxymel of Squill, B.P.C Tincture of Orange I.P Tincture of Capsicum, B.P.C Compound Tincture of Gentian Tincture of Lemon Tincture of Squill, B.P.C	Compound Tincture of Benzoin Tincture of Myrrh, B.P.C Tincture of Tolu, B.P.C

1.3: Modifications of the General Processes of Maceration

- **Repeated maceration** may be more efficient than a **single maceration**, since an appreciable amount of active principle may be left behind in the first pressing of the marc.
- The repeated maceration is more efficient in cases where active constituents are more valuable.
- **Double maceration** is used for concentrated infusions which contain volatile oil, e.g. **Concentrated Compound Gentian Infusion.**
- Where the marc cannot be pressed, a process of **triple maceration** is sometimes employed.
- The total volume of solvent used is however large and the second and third macerates are usually mixed and evaporated before adding to the first macerates.

- This precludes, the use of the process for preparations containing volatile ingredients.
- In a few cases, it is desirable to change the physico – chemical nature of the solvent during a single maceration process.
- Opium Tincture is prepared by using change of the physico-chemical nature of the solvent as indicated below:
- First pouring boiling water over the sliced opium to disintegrate it.
- Then, after macerating for six hours, 90% alcohols are added to the cold mixture and maceration is continued for a further 24 hours.
- The addition of the alcohol during the second period of maceration prevents the solution of much of the gummy material in the final tincture.

1.4: Large Scale Extraction Procedures

- Large scale operation demands modification of many extraction processes.
- In case of jar or vessel containing a small amount of solvent (500 to 1000ml) occasional shaking is no problem.
- But, for industrial batch where a large amount of solvent and the vessels having the huge weight, diameter and height, there will be a considerable difficulty in shaking the vessels.
- There are alternative methods of agitation that are just as effective but much simpler to put into practice.
- **In addition, economics become increasingly important and one of the most important objectives is to improve the efficiency of extraction so that less solvent is needed and evaporation requirements for concentrated products are reduced.**
- By reducing the cost of evaporation, it has the further advantage of minimizing the heat damage to thermo-labile constituents.

1.5: Modified Large Scale Maceration Processes

1.5.1: Circulatory Extraction

- The efficiency of extraction in a maceration process can be improved by arranging for the solvent to be continuously circulated through the drug. as indicated in the Fig., given below.
- Solvent is pumped from the bottom of the vessel to the inlet where it is distributed through spray nozzles over the surface of the drug.
- The movement of the solvent reduces boundary layers, and the uniform distribution minimizes local concentration in a shorter time.

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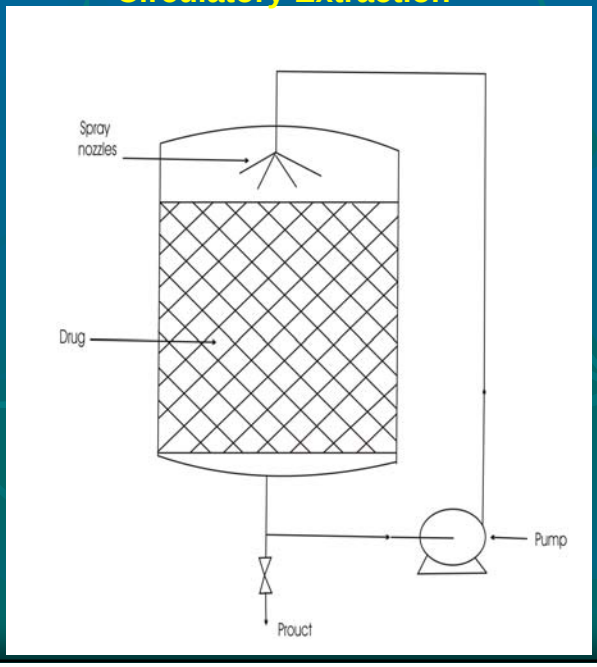
Circulatory Extraction



1.5.2: Multiple Stage Extraction

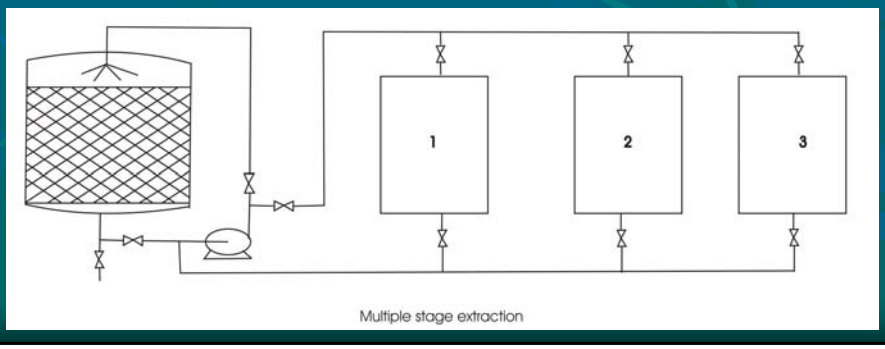
- Like the normal maceration process, however, extraction is incomplete, since mass transfer will cease when equilibrium is set up. This problem can be overcome by using a **multistage process.**
- The equipment needed for this method is a vessel for the drug, together with a circulating pump and spray distributors, and a number of tanks to receive the extracted solution.
- The extractor and tanks are connected with piping and valves as shown in Fig. so that anyone of the tank may be connected to the extractor for the transfer of solution.
- Examination of these procedures showed that each batch of drug is treated several times with solvent and that, once a cycle is in process, the receivers contain solution with the strongest in receiver 1 and the weakest in receiver 3.

Advantages:

- The drug is extracted as many times as there are receivers – in this case, three. If more extraction stages are required, it is only necessary to have more receivers.
- The last treatment of the drug before it is discharged is with fresh solvent, giving maximum extraction.
- The solution is in contact with fresh drug before removal for evaporation, giving the highest possible concentration.

Procedure

- Fill extractor with drug, add solvent and circulate. Run off to receiver 1.
- Refill extractor with solvent and circulate. Run off to receiver 2.
- Refill extractor with solvent and circulate. Run off to receiver 3.
- Remove drug from extractor and recharge. Return solution from 1 to extractor. Remove for evaporation.
- Return solution from 2 to extractor and circulate. Run off to receiver 1.
- Return solution from 3 to extractor and circulate. Run off to receiver 2.
- Add fresh solvent to extractor and circulate. Run off to receiver 3.
- Remove drug from extractor and recharge. Repeat cycle.



Multiple stage extraction

1.5.3: Extraction Battery

- In the normal percolation process, the percolate is not of maximum concentration and as such very dilute.
- The ideal situation would be to have maximum concentration.
- Continuous extraction devices of this type are used where large amounts of single material are handled.
- It can be achieved by treating it as a stage wise process.
- In this process a series of vessels are used and extraction is semi – continuous.

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Equipment

- Equipment is described as an extraction battery and consists of a number vessels with inter connecting pipe work.
- Vessels are so arranged that solvent can be added to and the product taken from any vessel.
- These vessels can, therefore, be made into a series with any of vessels as the first of the series.
- The use of extraction battery is illustrated in Fig. given below, where simplest arrangement of three vessel is shown

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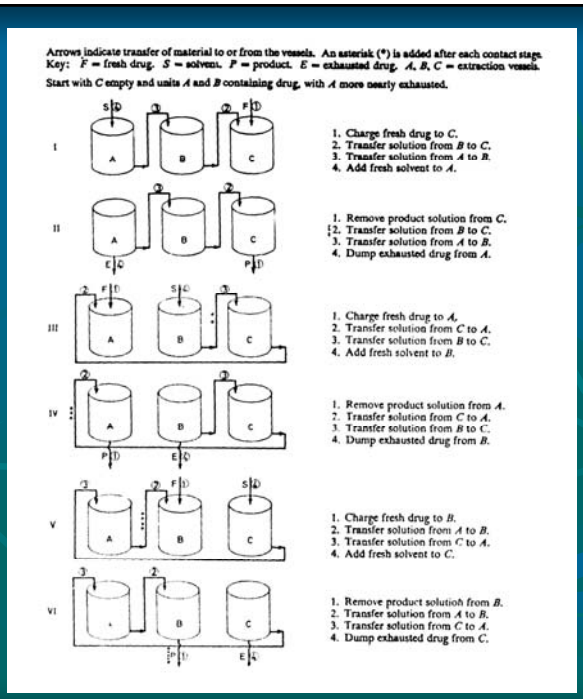

2. Percolation
(Exhaustive Extraction)

2.1: Process

- Organized vegetable drug in a suitably powdered form.
- Uniform moistening of the powdered vegetable drugs with ***menstruum*** for a period of 4hours in a separable vessel **(Imbibition).**
- Packed evenly into the percolator.
- A piece of filter paper is placed on surface followed by a layer of clean sand so that top layers of drugs are not disturbed.
- Sufficient ***menstruum*** is poured over the drug slowly and evenly to saturate it, keeping the tap at bottom open for passing of occluded gas to pass out.

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- Sufficient ***menstruum*** is also added to maintain a small layer above the drug and allowed to stand for 24 hours.
- After maceration, the outlet is opened and solvent is percolated at a control rate with continuous addition of fresh volume.
- 75% of the volume of the finished product is collected.
- Marc is pressed and expressed liquid is added to the percolate giving 80% to 90% of the final volume.
- Volume is adjusted with calculated quantities of fresh ***menstruum***.
- Evaporation and concentration to get finished products by applying suitable techniques and apparatus

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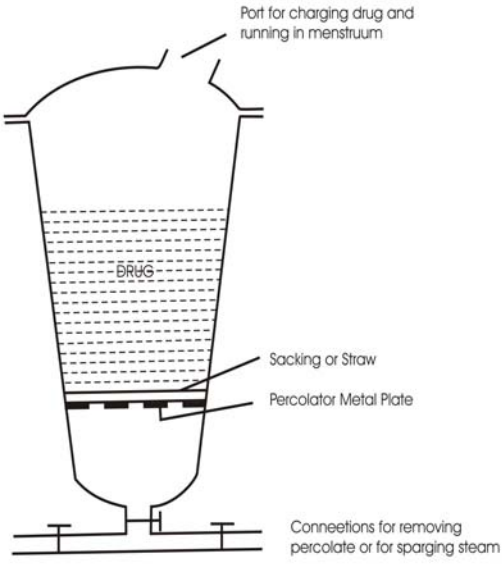

Commercial scale (about 1 ton capacity) percolator

2.2: Modifications of the General Process of Percolation

In general process of percolation, particularly in the manufacture of concentrated preparations like liquid extracts, the following problems may arise:

a) If the active substances are thermo-labile, evaporation of large volume of dilute percolate, may result in partial loss of the active constituents.

b) In the case of alcohol- water mixture, evaporation results in preferential vaporization of alcohol leaving behind an almost aqueous concentrate **which may not be able to retain the extracted matter in solution and hence get precipitated**.

In such cases the modification in general process of percolation is required as given below:

2.2.1: Reserved Percolation

- In this case the extraction is done through the general percolation procedure.
- At the last, the evaporation is done under reduced pressure in equipment like a **Climbing evaporator** to the consistency of a soft extract (semi solid) such that all the water is removed.
- This is then dissolved in the reserved portion which is strongly alcoholic and easily dissolves the evaporated portion with any risk of precipitation.

2.2.2: Cover and Run Down Method

- This is the process which combines the maceration and percolation techniques.
- This process can not be used for the materials which contain **volatile principles or those that undergo change during the evaporation stage.**
- This procedure is advantageous because industrial methylated spirit may be used for extraction instead of the costly rectified spirit.
- **The detailed procedure is as follows:**
- After the **imbibition** stage the material is packed in a percolator.
- Macerated for few hours with suitable diluted industrial methylated spirit.

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- The liquid is run off and the bed is covered with more of the ***menstruum.***
- Macerated as before and the second volume of the extract is collected.
- This process is repeated several times with the later weaker extracts used for extraction of a fresh batch of the drug.
- More concentrate fractions are evaporated under reduced pressure to free from the toxic methanol.
- Concentrate is diluted with water and ethanol to produce correct concentration of alcohol and active principle.

2.3: Percolators

Different types of percolators are used for small and large scale extraction

2.3.1: Small scale or laboratory scale extraction

The processes for the manufacture of concentrated preparations by maceration and percolations are involved in extraction followed by the evaporation of solvents. The two operations are combined in **continuous extraction process**.

(A) Soxhlet Apparatus

- On the laboratory scale, the apparatus consists of a flask, a soxhlet extractor and a reflux condenser.
- The raw material is usually placed in a **thimble** made of filter paper and inserted into the wide central tube of the extractor.
- Alternatively the drug, after **imbibition** with the ***menstruum*** may be packed into the extractor taking care to see that the bottom outlet for the extract is not blocked.
- Solvent is placed in the flask and brought to its boiling point.

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- Its vapour passes up the larger right hand tube into the upper part of the drug and then to the condenser where it condenses and drops back on to the drug.
- During its percolation, it extracts the soluble constituents.
- When the level of the extracts reaches the top level of syphon tube, the whole of the percolates syphon over into the flask.
- The process is continued until the drug is completely extracted and the extract in the flask is then processed.
- This extraction is **series of short maceration.**

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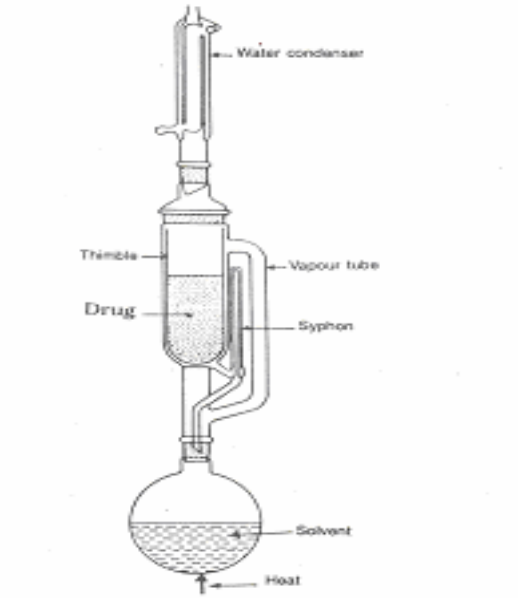

Soxhlet apparatus for hot extraction

(B) Official extractor (BP, IP etc.)

Such type of extraction are described in the official monographs (BP, IP etc.) and illustrated in figure given below:

- In such cases, the extraction is a continuous percolation extraction procedure.
- In this apparatus, vapour rises through the extraction chamber passing the drug container; the vapour condenses in the reflux condenser and returns through the drug taking the soluble constituents to the flask.

The limitations of this process are:

- It is not useful when the raw materials contain **thermo-labile active constituents** because the extraction is carried out at an **elevated temperature**, and the extract in the flask is also maintained in the hot condition until the process is complete.
- It can be used only with pure solvents or with solvent mixtures forming azeotropes.
- If an ordinary binary mixture is used as the ***menstruum***, the composition of the vapour will be different from the liquid composition.

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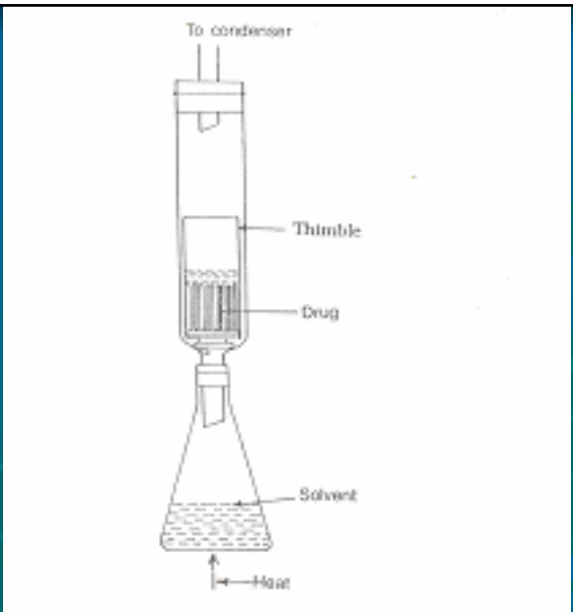
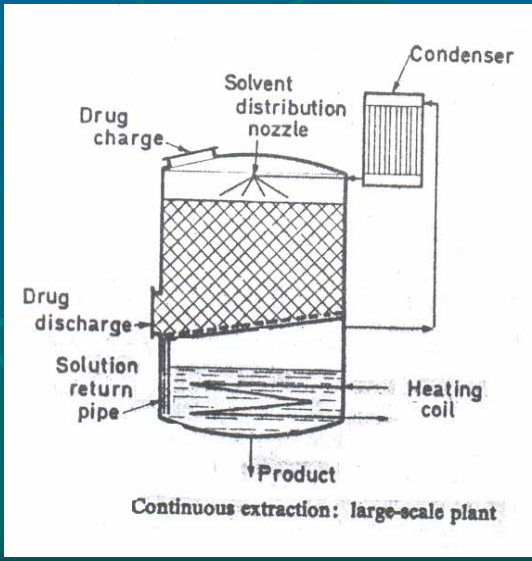


Apparatus For Continuous Extraction Of Drugs

Similar methods can be used in **large scale production:**
A typical industrial continuous extraction is shown in fig. given below in which the principle of operation resemble the laboratory equipments



2.3.2: Large Scale Extractor

- The figure given below shows a type of percolator used in the industrial scale.
- The drug is supported on a perforated metal plate covered with a layer of sacking or straw.
- The percolator is provided with a removable lid which contains portholes for packing the drug, for running in the solvent and for observing the flow of solvent.
- The outlet from the percolator is fitted with a tap and pipe line to remove the percolate for subsequent processing or to use it as a ***menstruum*** for the second percolator in series for more efficient use of the ***menstruum*** by carrying out the extraction in a countercurrent manner.
- **On a small scale copper percolators were originally used but these are now largely replaced with percolators made of glass or stainless steel.**

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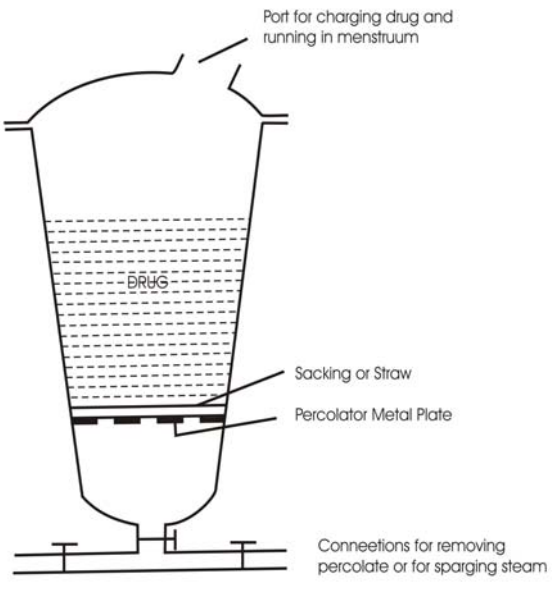

Commercial scale (about 1 ton capacity) percolator

3. Infusion

3.1: General Consideration

- Infusions are dilute solutions containing the readily-soluble constituents of crude drugs.
- Formerly, fresh infusions, prepared by macerating the drug for a short period in cold water or boiling water were used.
- **Now, infusions are usually prepared by diluting one volume of a concentrated infusion to ten volumes with water**.
- Concentrated infusions are prepared by modified percolation or maceration process, which after dilution with water, resemble in potency and aroma the corresponding fresh infusion.
- Infusions are liable to fungus and bacterial growth, and it is necessary to dispense them within twelve hours of their preparation.

3.2: General method for preparing fresh infusion

- The drug is usually coarsely powdered, **very fine powder being avoided** (50 gm).
- Moisten the drug in a suitable vessel, provided with a cover, with 50 ml of cold water.
- Allow to stand for 15 minutes.
- Then add 900 ml of boiling water, cover the vessel tightly.
- Allow it to stand for 30 minutes.
- Then strain the mixture, pass enough water to make the infusion measure 1000 ml
- Some drugs are supplied in accurately weighed in muslin bags for preparing specific amounts of infusion.
- If the activity of the infusion is affected by the temperature of boiling water, cold water should be used.
- As the fresh infusions do not keep well, they should be made **extemporaneously and in small quantities.**

3.3: Preparation of Concentrated Infusions

- The official monographs also recognize certain “concentrated infusions” in which 25% alcohol is added during or subsequent to the infusion process.
- Concentrated infusions are especially prepared in which the active and desirable principles of drug are equally soluble in water or in the ***menstruum*** used for both concentrate and infusions.

4. Evaporations

- One of the quality- relevant parameter is the evaporation of the eluate to the soft extract.
- The state of art are cautious vacuum evaporation apparatus and evaporation temperatures not exceeding 55 ^{0}C.
- The temperature in correlation with the evaporation time is of special importance for quality of this step of manufacture, if the extract contains easily volatile or thermo- labile constituents.

5. Factors Affecting Choice of Extraction Process

The final choice of the process to be used for the extraction of a drug will depend on a number of factors, including:

5.1: Character of Drug

- If hard and tough (such as nux vomica) use percolation.
- If soft and parenchymatous (such as gentian) use maceration.
- If 'unpowderable' (such as squill) use maceration.
- If an 'unorganized drug (such as benzoin) use maceration.
- If preferable to avoid powdering (such as senna fruits) use maceration.
- **Thus, knowledge of the pharmacognosy of the drug is essential to selection of the extraction process that will give the best result.s**

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5.2: Therapeutic value of the drug

When the drug has considerable therapeutic value, the maximum extraction is required, so that percolation is used, as in belladonna. If the drug has little therapeutic value, however, the efficiency of extraction is unimportant and maceration is adequate; for example, "flavours" (lemon), or "bitters", (gentian).

5.3: Stability of drug

Continuous extraction should be avoided when the constituents of the drug are thermo-labile.

5.4: Cost of drug

- From the economic point of view, it is desirable to obtain complete extraction of an expensive drug, so that percolation should be used; Ginger is an example of this type.
- For cheap drugs, the reduced efficiency of maceration is acceptable in view of the lower cost of the process. In particular, the cost of size reduction to a powdered state is avoided, whereas this is a significant part of the percolation process.

5.5: Solvent

- If the desired constituents demand a solvent other than a pure boiling solvent or an azeotrope, continuous extraction should be used.

5.6: Concentration of product

- Dilute products such as tincture can be made by maceration or percolation, depending on the previous factors.
- For semi-concentrated preparations (concentrated infusions, for e.g.) the more efficient percolation process is used) unless the drug cannot be powdered or is not worth powdering, when double or triple maceration is chosen.
- Concentrated preparations, of which liquid extracts or dry extracts are example, are made exclusively by percolation, with the exception that continuous extraction can be used if the solvent is suitable and the constituents are thermo-stable.

5.7: Recovery of solvent from the marc

- The residue of the drug after extraction (often known as the marc) is saturated with solvent and if economic the latter is recovered.

6. Conclusions

- The spectrum of constituents obtained by steady state extractions (Simple macerations) differs from the spectrum obtained by exhaustive extractions (Percolation).
- By the use of motive extraction methods, the aid of stirring and shearing forces, changes of temperature and quality of extraction solvent may lead to extracts with a spectrum of constituents' similar (equivalent) to one obtained by percolation.
- Different manufacturing procedures have to be assessed as equivalent if the critical quality parameters of the specification are conformed to and if compliance with standards is proven by the results of a number of production batches.