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POST-HARVEST PROCESSING PROCEDURES*

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Raw herbs should be inspected and sorted immediately following harvest or collection. They are then subjected to a series of on-site primary processes, and in most cases, subjected to further processes at a processing facility. The exact processing methods may differ from one herb to another, and the guidelines therefore may need to be adjusted on a case-by-case basis.

Sorting (garbling): The sorting process serves as the first step to ensuring the purity and cleanliness of the herbs. After the bulk amount of the desired plant part has been harvested or collected, all extraneous and unwanted matter including dirt (for example, soil, dust, mud and stones), impurities (for example, insects, rotten tissues, untargeted/ extraneous medicinal plant(s) and/or plant part(s)), and residual non-medicinal as well as toxic part(s) must be removed from the medicinal part(s). Depending on the herb, the process may involve procedures such as:

* World Health Organization (2003) WHO guidelines on good agricultural and collection practices (GACP) for medicinal plants. World Health Organization, Geneva.

- Removing dirt and foreign substances;
- Discarding damaged parts;
- Peeling (to separate unwanted plant part(s) from the medicinal plant part(s) such as removing unwanted root bark from the roots or collecting stem bark from the stem);
- Sieving, trimming, singeing (to remove hairs or rootlets);
- Removal of residues of unwanted plant part(s) (for example, removing unwanted seeds from fruits and stripping leaves from stems).

Although in some cases sorting may be done by mechanical means, it is usually done by hand. Only staff who are suitably trained and equipped (for example, wearing gloves and a dust mask, etc. as appropriate) should carry out this work.

PRIMARY PROCESSING

Washing:

Raw herbs, especially roots, rhizomes and tubers, are usually washed with clean water and dried soon after harvest or collection. During the washing process, scraping and brushing may be necessary. It is generally recommended not to soak the herbs in water for an unnecessarily long period. Water should be changed as frequently as required. The use of water containing a low concentration of chlorine (for example, sodium hypochloride, bleach) to prevent microbial fermentation is recommended where and when possible or practical.

Leaching:

Some impurities can be removed by the action of running water over the raw herbs (leaching). The duration of leaching has to be controlled in order to prevent excessive loss of active ingredients.

Primary cutting: Bulky raw herbs that have

been harvested or collected may require primary cutting to reduce their size before transportation to the processing or manufacturing facility. Primary cutting is usually performed at or near the harvest or collection site.

Ageing:

The ageing process refers to storing the herbal materials for a period of time after harvesting or collection from the field prior to use. Herbs are generally aged in the sun or in the shade, depending on the specific herbal material. During the process of ageing, excessive water is evaporated and enzymatic reactions (such as hydrolysis of the glycone portion of glycosides) or oxidation may occur to alter the chemical composition of the herbal material. For example, in cascara (*Frangula purshiana* Cooper) bark, after proper ageing (at least one year, or having been artificially heated to speed up the process), the reduced forms of the emodin glycosides in the fresh bark are converted to monomeric oxidized emodin glycosides. The latter form of glycosides are milder cathartic agents, with reduced irritating effects that may cause vomiting and stomach upsets, and hence, are more suitable as a therapeutic agent.

Sweating:

A similar process known as sweating (for example, fermentation) involves keeping the herbal materials at a temperature of 45–65 °C in conditions of high humidity for an extended period, from one week to two months, depending on the plant species. The sweating process is considered a hydrolytic and oxidative process in which some of the chemical ingredients within the herbal materials are hydrolysed and/or oxidized.

The herbal materials are usually densely stacked between woolen blankets or other kinds of cloth.

For example, vanilla beans (*Vanilla planifolia* Jacks. ex Andrews) are well known to undergo repeated sweating between woollen blankets in the sun during the day and packed in wool-covered boxes at night for about two months. During this process, the vanilla pods lose up to 80% of their weight and take on the characteristic colour and odour of vanilla.

Parboiling (blanching):

After washing, certain herbal materials may undergo a parboiling or blanching process in which they are put into boiling water for a brief period without being fully cooked. Such a heating procedure may serve several purposes, such as improving storage life of the processed materials by gelatinizing the starch, preventing mould or insect contamination, easily drying, destroying enzyme activity to prevent the alteration of certain chemical constituents, and facilitating further processing such as removal of the seed coat of almonds.

Boiling or steaming:

The boiling process involves cooking the herbal materials in water or another liquid such as vinegar, wine, milk or other vehicle. In the steaming process, herbal materials are kept separate from the boiling water but have direct contact with the steam, resulting in a moist texture of the herbal materials. Often, the herbal materials are placed in a steamer or in a special utensil equipped with a flat frame suspended over boiling water. In some cases, the herbal materials are pre-mixed with excipient substances such as wine, brine or vinegar before being steamed. The boiling or steaming process serves to soften plant tissues, to denature enzymes present in the herbal materials, and/or to thermally degrade selected chemical constituents. At the same time, the excipient, if used, is absorbed into the plant tissues to become an integral part of

the processed herbal materials. For example, *Reynoutria multiflora* (Thunb.) Moldenke (synonym *Polygonum multiflorum* Thunb.) root is often steamed in the presence of a black bean (*Phaseolus vulgaris* L.) decoction in order to enhance its tonic effects. Boiling the raw herbs such as *Croton tiglium*, *Abrus precatorius*, *Nerium oleander* and *Gloriosa superba* L., in cow's milk is practiced in some traditional medicine contexts to reduce the levels of their toxic ingredients and thus diminish the toxicity of the herbal materials.

Baking or roasting:

The baking or roasting process is a dry-heating using indirect, diffused heat, where the herbal materials are put in a heating device. The herbal materials are often embedded in bran or magnesium silicate (talc) powder to ensure even heating over the entire surface at an elevated temperature for a specified period of time. Some herbal materials are wrapped in moistened papers during the roasting process. The exact temperature used and duration of baking or roasting vary from one herbal material to another. Some are baked or roasted until the surface colour turns yellowish brown; some may be further heated until charred. For example, nutmeg (*Myristica fragrans* Houtt.) and kudzu (*Pueraria Montana* var. *lobata* (Willd.) Sanjappa & Pradeep) root require roasting before they are used for medicinal purposes.

Stir-frying:

Stir-frying is a process in which the herbal materials are put in a pot or frying pan, continuously stirred or tossed for a period of time under heating until the external colour changes, charred or even carbonized. Depending on the plant species, the stir-frying process may require the addition of adjuvants such as wine, vinegar, honey, saline and ginger juice, which would be

infused into the herbal matrix to become an integral part of the processed herbal material. To ensure even heating over the surface of the herbal materials, sand, rice, bran, talc or clay can be admixed with the herbal material during stir-frying.

For example, liquorice (*Glycyrrhiza glabra* L. and *G. uralensis* Fisch.) root and rhizome and *Astragalus* roots (*Astragalus mongholicus* Bunge or *A. membranaceus* (Fisch.) Bunge) are often stir-fried with honey for the preparation of decoction slices, whereas the *Salvia miltiorrhiza* Bunge root is stir-fried with wine. Fresh ginger is often stir-fried with sand until the surface colour turns brown. In other instances, ginger can be further stir-fried over intense fire to a carbonized state for use as decoction pieces.

Fumigation:

Fumigation with sulfur dioxide has been employed in post-harvest handling of some herbs for the purpose of preserving colour, improving fresh-looking appearance, bleaching, preventing the growth of insects and inhibiting decay caused by moulds. Thus, the process has been frequently applied to herbal materials of light and bright colours to avoid “browning”. Due to concerns about the undesirable residues, this process should be avoided as far as possible. When a real need is identified, treatment should be carried out at the earliest possible stage and exclusively by adequately trained and qualified personnel, according to the specific recommendations for use. All relevant regulations (for example, limits on sulfite residue) should be complied with.

Irradiation:

In some cases, irradiation or ultraviolet light can be used to eliminate or reduce microbial load of the herbal materials. The use of these procedures has to comply with the national and/or regional regulations.

Advanced cutting, sectioning and comminution: When thoroughly dried, the herbal materials are processed by cutting and sectioning into convenient or specific sizes and shapes or forms for storage, direct use as decoction slices or pieces, and/or for further processing for the manufacture of herbal preparations or herbal dosage forms. Decoction slices or pieces are available in many Member States for direct use as herbal medicines. Where applicable, the entire, sectioned or cut herbal materials are comminuted or pulverized into powder form in accordance with common herbal medicines practice, for use as herbal dosage forms.

White and/or red ginseng products presented as root pieces, slices or in powder form prepared from appropriately dried roots of *Panax ginseng* C.A. Mey., marketed as herbal medicines, are good examples of herbal materials derived from simple processing procedures.

Other primary processing procedures: Other primary processing procedures may be applied to raw herbs at an early stage for the production of herbal materials, such as collection of gums or resins. Also included under the term primary processing are primary distillation of raw herbs to obtain crude essential oils and expression to obtain fresh juice. Such procedures are usually performed in the processing facility under GMP conditions.

Drying:

Unless used in the fresh state, the raw herbal materials need to be dried after being sorted and washed. In general, they must be dried as soon as possible to protect them from mould and other microbial infestation. Drying will also prevent tissue deterioration and phytochemical alteration caused by the actions of enzymes and microbial organisms. It will also facilitate grinding and milling, and converts the herbal materials into a convenient form for further processing. However,

attention must be given to the potential loss of volatile (for example, essential oil) constituents present in the fresh material.

The final moisture content for dried herbal materials varies depending on the tissue structure, but should ideally be below 12%. Information on the appropriate moisture content for a particular herbal material may be available from pharmacopoeias or other monographs.

Proper drying involves four major aspects: control of temperature, humidity, airflow and cleanliness of the air. The drying conditions are determined by the nature of the raw medicinal plant material to be dried (tissue structure and chemical composition) and by the desired appearance of the final form. The drying method used may have considerable impact on the quality of the resulting herbal materials. Hence, the choice of a suitable procedure is crucial. Information on appropriate drying methods and procedures for particular herbal materials may be available from pharmacopoeias or other authoritative monographs. Raw herbal materials are most often dried by sun-drying, shade drying or by artificial heat.

The drying conditions chosen should be appropriate to the type of the herbal material. They are dependent on the characteristics (for example, volatility and stability) of the active ingredients and the texture of the plant part collected (for example, root, leaf or flower). Generally, one of the following drying processes can be adopted.

Sun-drying:

Some herbal materials can be dried in the open air under direct sunlight, provided the climate is suitable. The duration of the drying process depends largely on the physical state of the herbal material and the weather conditions.

For natural drying in the open air, medicinal

plant materials should be spread out in thin layers on drying frames and kept away from sources of possible contamination such as vehicle exhaust, heavy dust and rain. They should also be protected from insects, rodents, birds and other pests, livestock and domestic animals. The material should be turned periodically to achieve uniform drying. The drying frames should generally be set up at a sufficient height (for example, 15 cm) above the ground. Efforts should be made to achieve uniform drying within the shortest possible time to avoid mould formation.

Shade-drying:

Herbal materials can be dried in the shade with or without artificial airflow to avoid direct exposure to strong sunlight. The drying process is slow, but it is preferred when it is necessary to maintain (or minimize loss of) colour of leaves and flowers. Low temperatures (relative to heat-drying) will also preserve most of the volatile and aromatic components by reducing evaporation.

Drying by artificial heat:

Drying by artificial heat can be faster than open-air drying and is often necessary on rainy days or in regions where the humidity is high. Drying of herbal materials may be done using ovens, stoves, rack dryers, solar dryers, tunnel dryers, belt dryers, other heating devices or open fires. The use of an open fire should be avoided as much as possible, as residues of combustion may introduce contamination. When an open fire is used, the area must be well ventilated. For artificial heat-drying, the temperature, humidity and other conditions should be governed by the physical nature of the herbal material being dried and the physical/chemical properties of its active ingredients. Over-heating may lead to an excessive loss of the volatile components and/or decomposition of chemical constituents. In

general, the temperature should be kept below 60 °C for bark and root and below 40 °C for leaves, herbs and flowers.

GENERAL ISSUES

Selection of processing method:

Herbal materials derived from the same species but processed by different methods may show significant differences in quality and therapeutic properties, owing to the influence of the treatment process on the chemical composition.

It is not uncommon to find different processing methods being used for the same herb or herbal material, depending on intended use. For example, raw (unprocessed) liquorice is used as an antitussive and expectorant; but after being stir-fried with honey or ghee, the processed liquorice becomes a tonic drug to be used for replenishing body strength.

Prior to processing, it is important to consult the national or regional regulatory standards and other literature sources to decide on the most appropriate method to use. Once a method has been adopted, adherence to the SOP is necessary to ensure batch-to-batch consistency. For industrial production, method validation should be adopted as part of the SOP.

Only suitably trained staff should carry out the work, which should be conducted in accordance with the SOP and national and/or regional regulations in the countries where the plants are grown/collected and manufactured and in which the end-users are located.

Temperature:

With in-processing procedures that involve heating, the temperature used is critical. It is necessary to ensure that the required temperature is achieved during the process. In some cases, preheating the equipment (for example, oven, frying pan and steamer) and/or the additives

(such as sand, bran and rice) is required before putting in the herbal materials. When heating equipment is used, it should be regularly calibrated.

Duration of procedure/treatment:

It is also critical to control the duration of the procedure or treatment of the herbal materials. Both over- and under-treatment will affect the quality of the resulting materials. Duration of the procedure or treatment should be monitored through adequate in-process controls performed on the basis of organoleptic alterations (such as changes in colour, odour, taste and texture) or changes in the contents of active chemical constituents with appropriate instruments or testing.

Use of adjuvants:

Common adjuvants used during the processing procedures include water, wine (for example, rice wine, wheat wine and sorghum wine), vinegar, honey, ginger juice, liquorice extract, ghee, brine and so on. Under special circumstances, other adjuvants such as cow's milk, goat's milk, animal bile, goat fat, cow's urine, butter, black bean extract, coconut water, tamarind juice, turmeric, lemon juice and mineral materials (for example, borax) have been used. The quality of adjuvants must be clearly defined and controlled (according to Pharmacopoeia and/or relevant regulatory requirements). The exact amounts and quality of these adjuvants used (the ratio of herbal material and the adjuvant) should also be consistent from batch to batch. In addition, the use of any materials derived from animals or animal products in any processing procedures should be evaluated for safety and contamination, especially with pathogens, prior to use. General guidance is available in Safety issues in the preparation of homeopathic medicines.

DOCUMENTATION:

All processing procedures that could affect quality and safety of herbal materials should be documented. Guidance for good documentation can be found in Good manufacturing practices for pharmaceutical products: main principles, as well as WHO guidelines on good agricultural and collection practices for medicinal plants. Thus, it is important to establish a record-keeping system so that all records are up to date, maintained and traceable for the entire processing procedures for each batch of herbal materials. Written processing records should include, but not be limited to, the following information:

- Name of herbal material – botanical name (binomial – genus, species, with the authority (abbreviations, if used, should follow internationally accepted rules)) and the plant family name of the medicinal plant are essential. If required by national legislation, synonyms and applicable subspecies, variety, cultivar, ecotype or chemotype should be documented; if available, the local and English common names should also be recorded;
- Plant part(s) of the medicinal plant or herb;
- Stage of vegetative development, for example, flowering and fruiting, vegetative maturation;
- Site/geographical location (if possible, based on GPS data,) and time of harvesting/collection; state of the medicinal plant or herb (for example, fresh or dried);
- Batch number, batch size and any other identification code;
- Name of supplier;
- Dates of receipt of the material, processing of the material, and completion of the process;
- Name of person in charge of the processing, and person in charge of batch release; example, drying, washing and cutting, including drying time and temperatures, and size of herbal material);
- Gross weight of the plant material before and after processing;
- Method used for special processing;
- Details of the procedures (master formula), including descriptions of the utensil and equipment used, steps of operation, manufacturer, specification, amount and quality grade of the adjuvant (wine or vinegar) and/or other substances (sand, bran) used, temperature control, length of processing time, after-process steps (cooling, drying, cutting), and other relevant information;
- Details of animal-derived materials or adjuvants used and their microbiological certificates, if applicable;
- Batch production – detail deviations from or modifications of the master formula;
- In-process control, for example, organoleptic changes of the herbal material before and after processing (such as change in colour, shape, texture, odour and taste);
- Quality control parameters, grades and/or specifications, and assay results, where appropriate, of active ingredient(s), markers or chemical reference standard(s);
- Storage conditions and containers; and
- Shelf life/retest period.