

# Influence of Storage Conditions on Quality Attributes of Medicinal Plants



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## Introduction

The healing power of plants is as old as the appearance of the human species on Earth. The first civilizations realized that some plants contained, in their essences, active principles which when used in the combating disease revealed empirically their curative power, representing an important therapeutic resource [1-4]. Approximately 25% of the drugs prescribed worldwide are derived from plants and, according to the World Health Organization (WHO), its great use is due to the fact that traditional medicines ensure, for all population, access to health care [2]. The Brazilians are, more and more, betting on treatments based on medicinal plants and herbal medicines. Between 2013 and 2015, the search for these products in the Unified Health System (UHS) more than doubled, growing 161%. In 2013 about 6 thousand people went to some primary care pharmacy to receive the inputs; in 2015 this demand has reached almost 16 thousand people.

The initiative, created by the Ministry of Health to ensure safe access and rational use of medicinal and phytotherapeutic plants in the country, is already present in about 3,250 units of 930 Brazilian municipalities (SUS, 2016). To meet growing demand by medicinal and herbal plants with quality products, the raw material must go by the post-harvest process before being sent to the industry. This process is necessary because, the high water content present in fresh plants leads to rapid degradation of the active principles of interest, resulting in the reduction of its final quality.

## Importance of Storage in the Post-Harvest of Medicinal Plants

The post-harvest process of medicinal plants has great importance in the productive chain, because its direct influence on the quality and quantity of the active principles. Among the post-harvest processes, drying and storage are essential to maintain the product with the physical and chemical characteristics closer

to those found in the fresh plant, and failures in any of these steps influence the quality of the final product. Drying, if not performed properly, can compromise the content of active ingredients while, incorrect storage can lead to loss of material, whether for physical or biological reasons [5,6]. Medicinal plants are often stored for long periods, before being used as raw material for the manufacture of various products [7]. However, improper storage can result in physical, chemical and microbiological changes [8,9]. According to ANVISA [10], the storage period indicated for medicinal plants is one year, however, a longer period of validity may be accepted if the manufacturer presents results of stability tests that proves the maintenance of the characteristics of the product during the proposed period.

## Purpose of the Storage of Medicinal Plants

The storage and conservation of medicinal plants have the purpose of avoiding the deterioration of its quality, maintaining the qualitative and quantitative aspects after drying, by the development of ideal conditions of temperature and relative humidity, avoiding the attack of microorganisms, fungi and insects during the period of storage. During storage, metabolic activity must be reduced, making medicinal plants less susceptible to deterioration. This can be achieved by reducing the water content of the product to safe levels, cooling or use of modified atmosphere in the system in which the medicinal plants are stored [7,11,12].

## Researches that evaluated quality attributes of medicinal plants stored under different conditions

Several studies were carried out aiming at the stability of the active principle medicinal plants during storage. The following will be presented some works in which, the conditions of temperature, type of packaging, method of packaging and contamination (bacterial and fungal) influenced the physical and

chemical characteristics of medicinal plants. The storage time may influence the concentration of the chemical components present in the essential oil. Rowshan, et al. [13] evaluating the influence of different storage conditions, refrigerator (-4 °C), freezer (-20 °C) and ambient temperature (25 °C), composition of the essential oil of aerial part of *Thymus daenensis* Celak, observed that, although the freezer maintained the percentage of components of the essential oil closer to that observed at the start of storage, storage at ambient temperature did not impair the quality of the essential oil, and also provided caused some components of the oil to passed for chemical reactions and converted to other compounds of interest, such as thymol (from 27.4 to 34.7%) and carvacrol (from 28.8 to 35.7%). Jesus et al. [14] studying the effect of two packing temperatures (environment: average of 32 °C; and freezer: -20 °C) during storage, on the quality of essential oil of *Hyptis pectinata* L. Poit., also observed changes in the concentration of the chemical constituents of this oil. The storage of essential oil at the ambient temperature resulted in higher concentrations of  $\beta$ -elemene,  $\alpha$ -copaene, germacrene D, caryophyllene oxide and (E, E) - $\alpha$ -farnesene and lower concentrations of  $\alpha$ -humulene and  $\beta$ -caryophyllene, when compared to the results obtained from the storage of essential oil in the freezer.

Another important factor to be taken into account in the storage of medicinal plants, is the type of packaging. The recommended packaging for storing leaves are: paper bags, polyethylene bags, cardboard boxes and paper bags type double kraft with an inner layer of non-toxic polyethylene [15]. Using polypropylene bags to store dry samples of whole and ground leaves of *Ocimum selloi*, and evaluating the effect of storage time on the yield and chemical composition of the essential oil of this plant, Costa et al. [16] observed a marked reduction in the yield of essential oil both of the whole leaves and of the ground leaves during a year of storage. However, the yield obtained from whole leaves was significantly higher than that of the ground leaves. In general, during all the period evaluated, the methyl-chavicol, the major compound, was present with a higher relative concentration in the whole leaves than in the ground leaves, presenting decrease over storage time.

Chaliha, et al. [17] compared the effect of high barrier packaging (LDPE, PVDC coated with PET/CCP; and PET/PET/Foil/LDPE) during the storage of *Syzygium anisatum*, *Tasmannia lanceolata* and *Backhousia citriodora*, concluding that, the traditional packaging of LDPE presented higher losses of volatile compounds during the storage of *Backhousia citriodora* (loss of 87%), followed by PVDC packaging followed by PVDC packaging coated with PET/CCP (loss of 58%) and PET/PET/Foil/LLDPE (loss of 23%). The losses of volatile by *Syzygium anisatum* e *Tasmannia lanceolata* during storage in PVDC coated with PET/CCP and PET/PET/Foil/LLDPE was less than 30%.

Also evaluating the influence of high barrier packaging (PET/PPmet/PE and PET/Al/PE), Zorić et al. [18] stored samples of *Prunus cerasus* var. Marasca during one year at different temperatures (4, 20 e 37°C), and evaluated the stability of the polyphenols, color and sensorial characteristics, observed that the minimum loss in polyphenol content occurred at temperature of 4 °C and three

months of storage. In addition, storage on both types of packaging with temperatures of 4 and 20 °C, preserved sensory and dark red features. The packaging method used to store medicinal plants during the storage also affect quantitatively and qualitatively the essential oil. Ebadi et al. [19], investigating the effect of packaging methods (air, nitrogen or vacuum packing) during storage on the content and composition of essential oil of *Lippia citriodora* Kunth.

Observed that the leaves of *Lippia citriodora* Kunth. stored with nitrogen presented higher essential oil content and a higher percentage of limonene at the end of eight months of storage, however, the leaves stored under vacuum preserved a higher percentage of citral in the same period. In addition, chemical reactions occurred providing that some essential oil components were converted into limonene in all packaging methods, ranging on average from 13.7 to 21.8%. Investigating the effect of modified atmosphere packaging (LFO-160: 130 mL O<sub>2</sub>.kg-1h-1; and ML-7525: 510 mL O<sub>2</sub>.kg-1h-1) during storage of *Hippophae rhamnoides* Linn, Li et al. [20] observed that the samples stored in modified atmosphere packaging presented higher antioxidant activity, especially those in LFO-160 packages. Finally, as pointed out earlier, the attack of micro-organisms, fungi and insects affect both qualitatively and qualitatively the medicinal plants. The microbial load depends on the temperature, humidity, handling and storage of the processed or unprocessed medicinal plants, and may increase morbidity and mortality, especially in patients with compromised immune systems and who are vulnerable to infections [21-23].

Evaluating the microbiological quality regarding the presence of filamentous fungi in the herbs of the type *Peumus boldus* Molina, *Pimpinella anisum* L. and *Matricaria chamomilla* L. commercialized in the city of Campina Grande - Paraíba, Santos et al. found toxigenic fungi such as *Aspergillus* sp., *Penicillium* sp. and *Fusarium* sp., the first being present in all samples evaluated. Also identified the fungi *Exophiala* sp. and *Fonsecaea* sp., which have clinical importance and may cause ringworm. The way these plants are stored for commercialization and the lack of inspection makes the quality of commercialized plants questionable for obtaining teas, which can compromise the health of consumers when using these products. Considering antibacterial and antifungal compounds, Laher et al. [24] evaluating the effect of short-term storage on the efficacy and the phytochemical content of three medicinal plants popular in South Africa (*Ocimum basilicum*, *Senna petersiana* and *Hypoxis hemerocallidea*), observed that fresh samples presented better antibacterial activities (*Staphylococcus aureus* and *Escherichia coli*) and antifungal (*Candida albicans*) compared to the stored samples.

Vuuren et al. [23] analyzing the microbial contamination of five species of medicinal plants (*Helichrysum* sp., *Drimis sanguinea*, *Hypoxis* sp., *Hydnora abyssinica* and *Acacia xanthophloea*) from the traditional Faraday market in Johannesburg - South Africa, have identified fifteen bacterial contaminants, the most recurrent *Pantoea* sp. and five strains of *Bacillus* spp. (non-pathogenic). Microbial types are predominantly opportunistic pathogens. The implementation of good processing practices, therefore, clearly influence the quality and safety of medicinal products, especially in relation to microbial contamination [25,26]. In the current context,

in which there is growing demand for traditional medicines, because they have fewer side effects and be considered healthier, the storage is an important step, which if done properly, can overcome the seasonality of production, offer a safe product to the consumer and maintain the quality of the active ingredients for a long period of time.

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