



JAMBU DRYING WITH COLD AIR CIRCULATION

SECAGEM DE JAMBU COM CIRCULAÇÃO DE AR FRIO

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ARTICLE INF.	ABSTRACT
Received: 04/01/2015	<p>The purpose of this study was to evaluate the drying process of jambu using cold air which is a technology that can add value to the horticultural food, improve the production rates and help in waste reduction. Initially, the vegetable is washed in water in order to remove residual impurities. Then, the roots are removed. The raw material is sanitized with 200 ppm (mg.L⁻¹) of sodium hypochlorite (10 minutes). Therefore, the final rinse is carried out with a 5 ppm sodium hypochlorite bath for 10 minutes with the subsequent drainage of this water. The cold air-drying of jambu is performed under temperatures around 77°F using an air conditioning system. A dehumidifier is used in order to reduce the product's relative humidity (54.6 ± 2.87). The process takes place in a room with an area of 4 square meters that remains shut during the process, which lasts a total time of 44 hours. Later, the product is stored in a high protective package to avoid moisture. Jambu centrifugation is not performed because its leaves are fragile. The cold air-dried jambu is in accordance with the current legislation regarding microbiological aspects. Also, it is well accepted by consumers and its centesimal composition is similar to fresh jambu. Other drying techniques can also be applied, such as hot air and ultrasound. Thus, considering sanitary and sensory aspects and chemical composition, the commercialization of dried jambu is feasible in terms of transport and handling.</p> <p>Keywords: <i>Spilanthes oleracea</i> L., vegetable, postharvest, Spilanthol</p>
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RESUMO - A proposta do trabalho foi de avaliar a secagem de jambu com ar frio, tecnologia possível de agregar valor aos hortifrutícolas com maior aproveitamento da produção e redução das perdas. Inicialmente a hortalíça é lavada para retirada de resíduos da terra em água corrente. A seguir, são removidas as raízes. A matéria-prima é sanitizada com 200 ppm (mg.L⁻¹) de hipoclorito de sódio (10 minutos). Em seguida é realizado o enxágue final com 5 ppm de hipoclorito de sódio, durante 10 minutos com posterior drenagem dessa água. A secagem do jambu com ar frio é realizada com auxílio de ar condicionado a 25°C e um desumidificador de ambiente para reduzir a sua Umidade Relativa (54,6 ± 2,87), numa sala de 4 m² de área que permanece fechada durante o processo, com tempo total de 44 horas. Posteriormente o produto é acondicionado em embalagens com alta proteção ao vapor d'água. Não é realizada a centrifugação do jambu em função das suas folhas serem frágeis. O jambu seco com ar frio atende a Legislação vigente quanto aos aspectos microbiológicos, apresenta boa aceitação pelos consumidores, além de composição centesimal similar ao jambu *in natura*. O jambu pode ser seco também por outras técnicas de secagem como ar quente e ultrassom. Desse modo, considerando os aspectos sanitários, sensoriais e composição química, torna-se viável a comercialização do jambu seco, facilitando o transporte, manuseio e diminuindo o volume dessa hortalíça.

Palavras-chave: *Spilanthes oleracea* L.; hortalíça, pós-colheita; espilantol

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INTRODUCTION

Spilanthes oleracea L., popularly known as jambu, is a plant native to the Amazon widely used

as flavor in typical dishes of the Northern region of Brazil, such as the *tacacá* and *pato no tucupi*. It is also used in popular medicine for treating stomatitis,

colds and as a painkiller. (NASCIMENTO et al., 2013). The plant has important chemical properties of interest to the pharmaceutical industry, particularly because of its active ingredient, spilanthol (BORGES et al., 2012).

Spilanthol is an amide present in the leaves, stems and inflorescence of jambu described in several patents. It is the main chemical component of the jambu. (CAVALCANTE, 2008).

Being a leafy vegetable, the jambu, has high moisture content, and, thus, post-harvest Technologies should be developed to increase shelf life of this food and meet other markets. One possible technology to be used in the conservation of this vegetable is drying, which consists in the removal of part of a portion of the free water, as steam, with consequent reduction of water activity, which impacts microbial growth, enzymatic reactions and other chemical and physical reactions. (FANG & BHANDARI, 2011; KUROZAWA et al., 2014). Drying can increase shelf life by reducing weight and volume and lowering the costs of transportation and storage, and facilitate the use and diversify its offer. (JIN et al., 2014a).

Drying is an important method widely used in food processing (KOYUNCU et al., 2007). Due to the lack of adequate and timely processing, approximately one third of the world food production is annually lost (GUSTAVSSON et al., 2011). This loss is even greater in developing countries, where 30-40% of fruits and vegetables are wasted (KARIM & HAWLADER, 2005 a,b).

Cold air drying is a simplification of the lyophilization at atmospheric pressure, through the elimination of the freezing step. Water removal occurs in environments with low temperature and relative humidity, and it is kept in the liquid state during the entire process. (KUBOTA & CAL-VIDAL, 1987).

Thus, the present study aimed to present a literature review on jambu drying using cold air circulation.

Spilanthus oleracea L.

This vegetable is native to tropical Brazilian regions and is grown as an ornamental and medicinal plant in several parts of the world. (LENG et al., 2011). It is widely distributed in tropical and subtropical regions, including America, Northern Australia, Africa, Malasia, Borneo, India and Sri Lanka (YADAV & SINGH, 2010).

It belongs to the genus *Spilanthus*, family Asteraceae (Compositae). The genus *Spilanthus* contains 35 tropical species (SAVADI et al., 2010). The plant can be found in other parts of the world named as *Acmella ciliata* Kunth, *Spilanthus acmella*, *Cotula pyretharia* L., *Spilanthus fusca* MART and *Bidens fervida* Lan. Regarding its botanical characteristics, it is a small plant with yellow flowers, arranged in capitula. It is a perennial, semi-erect herb with decumbent branches (COSTA et al., 2013).

Popularly known as “jambu”, “agrião bravo” or “agrião do Pará”, its leaves and flowers cause a slight tingling and numbness in the tongue (NASCIMENTO et al., 2013). The leaves and stems are widely used in the state of Pará (Northern of Brazil) in typical recipes such as the “tacacá” and “pato no tucupi” or in rice and pizzas (COSTA et al., 2013).

The appropriate conditions of production such as preparation of the seed, transplants of the seedlings to the planting sites, irrigation, fertilization and soil coverage, as well as pest control, can be found in publications of (POLTRONIERI et al., 2000; HOMMA et al., 2011). Table 1 shows the technical and economic coefficients in jambu production (HOMMA et al., 2011).

Table 1. Technical and economic coefficients in the production of jambu considering one hectare, June 2011.

Items	Unit	Amount	Price (US\$)
Labor			
Seed	lb	0.17	0.00
Manure bird	lb	154.32	1,115.16
Mineral fertilizer	lb	220.46	66.38
Pesticide	lb	0.015	119.48
Preparation of the area	hour	25	165.94
Preparation of planting sites	hour	10	66.38
Sowing	hour	0.50	1.99
Transplantation	hour	20	132.75

“to be continued”

Table 1. Conclusion

Items	Unit	Amount	Price (US\$ ¹)
Labor			
Cultural treatments	hour	50	331.89
Harvest	hour	25	165.94
Wash	hour	10	66.38
Tying into bunches/packs	hour	20	132.75
Total cost	US\$ 2,365.04		
Yield	48,000 packs/ha		
Gross revenue	US\$ 3,982.74 /ha		
Net revenue	US\$ 1,593.09/ha		
Retail price	US\$ 0.08/pack		
Production cost	US\$ 0.05/pack		
Net income (pack)	US\$ 0.03/Pack		

¹US\$ 1.00 = R\$ 3.013 (04/30/2015)

Source: (HOMMA et al., 2011).

For the calculation of the operating cost of jambu planting an area of one hectare was considered as follows: standard areas measuring 20 m x 25 m (30 m²), totaling 192 planting sites, with 5760 m² of floor area. The space between each site would be 0.80 m, and the main rows would have a length of 2 meters at each interval of 25 meters, both vertically and horizontally. An average yield of 250 packs of jambu per planting site was adopted, totaling 48,000 packs, considering a productive cycle of 2 to 2.5 months, using crop rotation (HOMMA et al., 2011).

The average production of a planting site measuring 25 m x 1.20 m is 250 packs of jambu, and depending on soil fertility, cultural treatments and reduction of pests and diseases, it is possible to obtain up to 400 packs per planting site in the summer (POLTRONIERI et al., 2000; HOMMA et al., 2011). The time of greater intensity of jambu cultivation is in the wet season (ALBURQUERQUE, 1989). In general, jambu plants are harvested in packs (bundles) in the growing area, transported and then washed in a tank near the producer's house. The same water is reused several times for daily wash and disposed only on the subsequent day. This wash is the focus of contamination of the vegetables (BORGES, 2009). According to the producers, the size of these packs is a requirement of intermediate sellers. In 2011 they were sold to middlemen at US\$ 0.08 to US\$ 0.1/pack (HOMMA et al., 2011). In supermarkets and fairs they are sold in smaller packs, and in festivities their prices reach US\$ 0.33 to US\$ 0.49/pack because of their use in typical recipes (GUSMÃO et al., 2005).

The jambu is an important source of income for small producers in the cities of Pará because the plant has multiple uses: in medicine, in food as a

condiment and in ornamentation, gathering the essential elements for the establishment of a sustainable system (GUSMÃO et al., 2005).

Chemical composition of the plant

There is a growing interest in the use of vegetable and phytochemical materials throughout the world, which is associated to the search for a sustainable lifestyle. The substances extracted from the plants must have low toxicity and high degree of biodegradation (PITASAWAT et al., 1998; CHOOCHOTE et al., 1999). Therefore, phytochemicals extracted from plants have been used in nutraceutical products, pharmaceutical products, herbal medicines, spices, insect repellents, cosmetics, perfumes, among other purposes (RAMLAN & MOHAMAD, 2000).

S. oleracea L. is one of the most important medicinal plants, being a rich source of therapeutical compounds. (PRACHAYASITTIKUL et al., 2013). Phytochemically, the flowers, leaves and stems of *S. oleracea* L. reportedly contain aminoacids, alkaloids (PIERIS et al., 2001), phenolic compounds, coumarin, triterpenoids (PRACHAYASITTIKUL et al., 2009) and *N*-isobutylamides (*N*-isobutyl-2*E*,6*Z*,8*E*-decatrienamide - spilanthol, and(2*E*)-*N*-isobutyl-2-undecene-8,10-dienamide) (RAMSEWAK et al., 1999).

The *N*-alkylamides, a natural group of secondary metabolites found in different genera of plants (*Echinacea*, *Zanthoxylum*, *Heliopsis* and *Spilanthus*), are new and promising bioactive molecules (BOONEN et al., 2010a). The principle or metabolite that is considered more active in *Spilanthus oleracea* L. is an antiseptic amide, acid 2*E*, 6*Z*, 8*E*-deca-2,6,8 trienoic (spilanthol) (Figure 1).

Spilanthol is the most mordant component found in the *Spilanthesoleracea*L. (LENG et al., 2011).

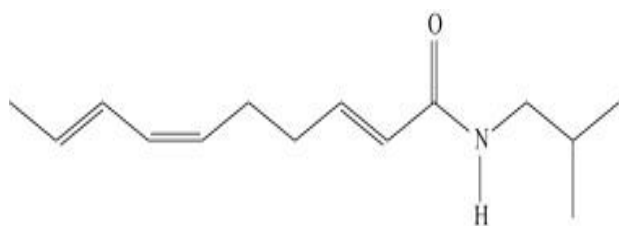


Figure 1 - Spilanthol structure. Source: (BOONEN et al., 2010b).

Biological activities

Besides its wide use in cooking, the jambu can be used for medicinal purposes because of its active principles such as saponins, spilanthines, affinins, phyosterins, cholines, triterpenoids and, particularly, spilanthol. In addition to these properties, the plant is also used as raw material in anti-wrinkle cosmetics (MARTINS et al., 2012). The main phytochemicals present in the genus *Spilanthes* are saturated and unsaturated ketones, alkamides, hydrocarbons, acetylenes, lactones, alkaloids, terpenes, flavonoids and coumarins. They are the main constituents responsible for the pharmacological activity (RADUNER et al., 2006). Due to the spilanthol amide, the jambu is widely used in pharmaceutical products, foods and health and body care products (PANDEY & AGRAWAL, 2009; SINGH & CHATURVEDI, 2012).

S. oleracea L. has been widely used in the traditional Indian medicine for the treatment of several sexual dysfunctions and is used to improve the sexual functions in men. (WONGSAWATKUL et al., 2008). (SHARMA et al., 2011) report that the ethanol extract of flowers of *S. oleracea* L. is a potent stimulator of sexual behavior in male rats, having aphrodisiac properties.

Other ethnopharmacological benefits associated to the jambu include its use in the treatment of rheumatism, inflammations, as a stimulant against stuttering, tongue paralysis, stomatitis, toothache, and headache and in the treatment of asthma, fever, sore throat, hemorrhoids and gum infections. Moreover, the extract is traditionally added to the nutritional and cosmetic supplement to accelerate the process of recovery of skin damaged by vasoconstriction (BOONEN et al., 2010b; PRACHAYASITTIKUL et al., 2013). Pharmacologically, *S. oleracea* L. is a potential vasodilator, antioxidant (WONGSAWATKUL et al., 2008) and immunomodulator (SAVADI et al., 2010). Previous studies demonstrated diuretic, antibacterial and anti-inflammatory activity

(RATNASOORIYA et al., 2004). It was also demonstrated that spilanthol in extracts of *S. oleracea* L. permeates the skin and oral mucosa (BOONEN et al., 2010a,b). Recently, a polysaccharide (ramnogalacturonan) has been isolated from leaves of *Acmellaoleracea*, which have gastroprotective activity against ethanol-induced acute gastric lesions in rats (NASCIMENTO et al., 2013). Also, (DOLUI & DEBNATH 2010) found that the methanol extract of leaves and flowers of *Spilanthes calva* have a significant repellent effect against *Helopeltistheivora*. A significant anti-inflammatory action has also been reported for the flowers.

Drying

Hot air drying is a simple and common method for drying vegetables. (LEONID et al., 2006). The disadvantages of hot air drying include low energy efficiency and lengthy drying during the falling rate period, as well as substantial degradation of product color and nutrients (DROUZAS et al., 1999; MASKAN, 2000; LEONID et al., 2006).

During the drying of broccoli, the heat reduces the retention of glucosinolates and vitamin C, as well as the activity of the enzyme myrosinase (JIN et al., 2014a). (VEGA-GALVEZ et al., 2009) showed that, with convective drying at the 122-194 °F temperature range, less than 40% of the level of vitamin C in sweet pepper was maintained. They also found that retention decreases with increasing temperature.

Another drying method is lyophilization. This is a process in which moist material is dried at sub-atmospheric pressure (AREVALO-PINEDO & MURR, 2006). Lyophilization has some different characteristics compared to conventional air drying, e.g. there is no oxidation because the sample is not exposed to air during the drying process. Therefore, the sensory and nutritional quality of food is maintained at a relatively short drying period and at low drying temperature. (WU et al., 2007).

Cold air drying is a simplification of the lyophilization process at atmospheric pressure, through the elimination of the freezing step. Water removal occurs in environments with low temperature and relative humidity, and it is kept in the liquid state during the entire process, so that products with intermediate moisture content can be obtained. This characteristic confers high stability to them without loss of plasticity. (KUBOTA e CALVIDAL, 1987).

The moisture retention capacity of cold air is very limited compared to that of hot air.

Nevertheless, when relative humidity reaches sufficiently low levels, this cold air is able to absorb moisture. (HALLOWELL, 1980).

There are few studies on cold drying of food. (BARBOSA et al.2014 a,b) examined the impact of cold drying of jambu on chemical, microbiological and sensory qualities of the product. Drying was performed at a temperature of 77 °F (77.86 ± 1.29), using air conditioning and environment dehumidifier to reduce its Relative Humidity (54.6 ± 2.87), in a room with an area of 4 m² that remained closed during the drying procedures for 44 hours.

The author concluded that the dried jambu has a centesimal composition similar to that of fresh jambu. Moreover, dried jambu complies with the current legislation regarding microbiological aspects. *Tacacá* with fresh and dried jambu is well accepted by the consumers. Thus, considering health and sensory aspects and the chemical composition, the commercialization of dried jambu is feasible. The **Figure 2** shows drying curve of jambu using cold air and **Figure 3** shows the drying curve of jambu at a temperature of 113°F

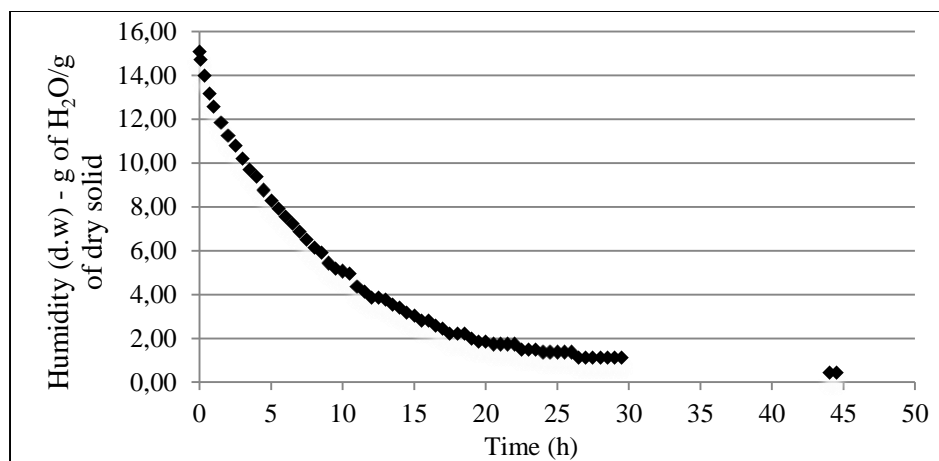


Figure 2 - Drying curve of jambu using cold air. Source: (BARBOSA et al., 2014b).

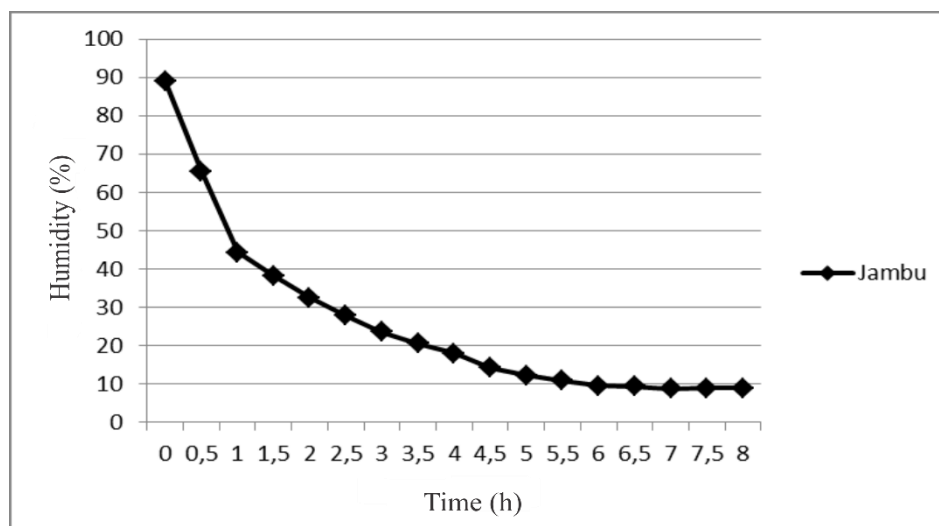


Figure 3 -. Drying curve of jambu using hot air. Source: (OLIVEIRA, 2014).

It can be seen that hot air drying is much faster than cold air drying. However, cold drying preserves the nutritional and sensory characteristics of the product.

Vieira & Cal-Vidal (1995) investigated the effect of several operating variables on cold drying of avocado cream. In the present study, drying was performed with a tunnel dryer, at temperatures of

41, 50, 59 and 68 °F and relative humidity levels of 10, 18, 30 and 40 %. The decrease in drying rate with increasing relative humidity was observed in all the samples. The final moisture content after a 30-hour drying period ranged from 18 % (UR=10 %) to 52 % (UR=40 %).

Kilic (2009) assessed the characteristics of cold drying and its effects on the quality of fish. The

drying temperatures used in the study were 39.2, 50, 59 and 68 °F, the speed was 7 m/s and the relative humidity was 40-50%. The author concluded that the drying process maintains the high quality of the fish. In jambu drying, the vegetable must first be washed to remove soil residues under running water. Then, the roots are removed with stainless steel knives, and the parts of the plant that are torn, shriveled and darkened at the ends are removed. The raw material is sanitized by immersion for 10 minutes in solution with 200 ppm (mg.L⁻¹) of Free Residual Chlorine (FRC). Then, final rinsing is performed with immersion in solution of 5 ppm (mg.L⁻¹) of FRC, during 10 minutes, with subsequent drainage of water. Jambu centrifugation is not recommended because its leaves are fragile. The cold drying process can be carried out in an air-conditioned room at 77 °F and using dehumidifier or equipment (e.g. tunnel dryer).

A large number of fruits and vegetables are produced in tropical and subtropical countries, and they are very attractive from a commercial point of view. However, because of seasonality, most of these products have a higher water content, which makes them susceptible to decomposition by microorganisms and chemical and enzymatic reactions. These fresh products are highly perishable and difficult to market in the fresh form in the country, as well as to be exported. (KUROZAWA et al., 2014).

Therefore, fruit and vegetable processing is essential to increase their shelf life and prevent post-harvest losses. Among the various methods used for preservation, drying is a process in which water activity is lowered by vaporization and sublimation, minimizing enzymatic and microbiological reactions. (KUROZAWA et al., 2014).

Drying is traditionally defined as an operation that converts a liquid, solid or semi-solid material into a solid product with significantly lower moisture content (ERBAY & ICIER, 2010). Convective drying is the most widely used technique for preserving foods for long periods (JIN et al., 2014b). Convective drying of food is a process in which the convective medium (usually air) heats the surface of the food. This heat produces the evaporation of water, and excess heat increases the temperature. (GARCÍA-ALVARADO et al., 2014).

Although drying may provide dehydrated products with increased shelf life (around 1 year), the quality of dry food is significantly affected by the changes that occur during processing and/or storage, and can be drastically since the beginning (origin of the raw material). So, it is important to

minimize chemical changes, such as enzymatic reactions, non-enzymatic and enzymatic darkening and oxidation of lipids and pigments, to maximize the retention of nutrients during drying (KUROZAWA et al., 2014).

The drying process causes many changes in physical, sensory and nutritional properties of foods. The main challenge of the food drying industry is producing food with desirable taste, size, color and texture (AGHBASHLO et al., 2014).

These changes are of physical, chemical and/or biochemical nature. Although the physical changes appear to be more directly related to microstructural changes of a material, these microstructural changes affect other types of changes. This happens because the changes may affect the path through which heat and mass are transferred. And this path, in turn, affects the drying characteristics of a material, and, consequently, time/temperature, which are directly related to biochemical and/or chemical changes. When food containing a bioactive compound to be later extracted is dried, microstructural changes can also affect the release of this compound from the origin of the food, thus affecting the ability to extract the compound from its structure. (HIRANVARACHAT et al., 2012).

The drying conditions have significant impact on the quality attributes of the dried product. High drying temperatures reduce drying time, but may result in poor product quality, forming a film on the food surface, with consequent increased energy consumption (HO et al., 2002). On the other hand, lower drying temperatures may improve product quality, but reduce drying rate, extending the drying period. Intermittent drying is one of the technical solutions to this problem, since it reduces the drying time and improves product quality (KOWALSKI & PAWŁOWSKI, 2011).

In food industry, the foods are dried in their natural form or after handling. There are more than 400 types of dryers and many of them have been used commercially (ERBAY & HEPBASLI, 2014).

The drying method can have a negative impact on quality, e.g., hot air drying showed a negative effect on the antioxidant properties of mango (DORTA et al., 2012).

CONCLUSION

Considering the benefits of drying, sanitary and sensory aspects and chemical composition reported by studies of jambu, the commercialization of dried jambu is technically feasible, facilitating the

transport and handling of this vegetable and reducing its mass.

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