

## Microbiological and sensory evaluation of Jambu (*Acmella oleracea* L.) dried by cold air circulation

Alan Franco BARBOSA<sup>1\*</sup>, Dilcilene Fagundes SABAA-SRUR<sup>2</sup>, José Guilherme Soares MAIA<sup>3</sup>,  
Armando Ubirajara Oliveira SABAA-SRUR<sup>1,4</sup>

### Abstract

The aim of this study was to evaluate the microbiological and sensory quality of the Jambu (*Acmella oleracea* L.) *in natura* and dried by cold air, and the determination of its drying curve. The microbiological analysis were performed to *Salmonella* spp, the coagulase-positive *Staphylococcus*, and coliforms in the both Jambu samples, at 45 °C. Tacacá, the typical food dish of Pará state, Brazil, has showed good consumer global acceptance in the sensory evaluation of Jambu *in natura* (score of 8.00 ± 1.46) and dried (score of 8.67 ± 0.66). Both samples, Jambu *in natura* and dried by cold air, were by the current legislation regarding the microbiological aspects, this is the absence of *Salmonella* spp, coagulase-positive *Staphylococcus* <1×10<sup>1</sup> CFU/g, and coliforms <3 MPN/g, at 45 °C. Thus, considering sensory and health aspects, the commercialization of dried Jambu becomes viable, facilitating its transportation and handling, as well as for reducing its vegetable mass.

**Keywords:** Jambu; *Acmella oleracea*; dehydration by cold air; sensory acceptability.

**Practical Application:** Considering sensory and health aspects, the commercialization of dried Jambu becomes viable.

### 1 Introduction

*Acmella oleracea* L., popularly known as Jambu, is a native plant of the Amazon region. It is often used as flavoring in dishes from Northern Brazil, such as Tacacá and Pato-no-tucupi. Also, it is used in the traditional medicine to treat stomatitis, influenza and as an analgesic product (Nascimento et al., 2013). Important chemical property of the plant has aroused the interest of the pharmaceutical industry, due to the presence of the active ingredient known as spilanthol (Borges et al., 2012).

Jambu is a herbaceous species presenting high moisture content and short shelf life. Thus, it requires post-harvest technology to preserve its long-term quality, given the transport and trading in more markets that are distant. Drying could be the possible preservation technique. It means that removing part of moisture can reduce the water activity and affect microbial growth, enzymatic reactions and other physical and chemical reactions. The drying results can increase the shelf life of food, reducing weight and volume, and decreasing the costs of transportation and storage. Also, can facilitate the use and the offer diversification of new foods.

Cold drying is a simplified lyophilization process, under atmospheric conditions, which eliminates the freezing stage. Water removal occurs at low temperatures and relative humidity, and the food sample is kept in the liquid state through all the drying process (Kubota & Cal-Vidal, 1987).

Sensory tests are used for many purposes, such as quality control, process and product development and optimization, and for the understanding of consumer reaction to the product. The sensory analysis is used to achieve good food quality, with minimal chances of error or uncertainty (Teixeira, 2009). The effective methods represent the consumer opinion, based on the evaluation how much the consumers like or dislike the product (Isaac et al., 2012). There are several scales to measure the acceptance, and the hedonic scale is one of the most used. Many forms of hedonic scales are commonly used to measure quantitatively the consumer acceptances of food products (Lim, 2011).

The RDC Resolution No. 12 from Agência Nacional de Vigilância Sanitária (Brasil, 2001), regulates the microbiological standards for vegetables *in natura* and dried vegetables. This resolution has established the absence of *Salmonella* spp for both products and sets the maximum values for coliforms (10<sup>3</sup> MPN/g) and coagulase-positive *Staphylococcus* (10<sup>2</sup> CFU/g), for the dry vegetables.

Studies on food drying curve are needed to optimize the drying process and the obtaining of products with good quality to satisfy the consumer demands. Thus, the aim of this study was to evaluate the microbiological and sensory quality of the Jambu *in natura* and dried by cold air, as well as determine the drying curve of this vegetable.

Received 20 Aug., 2015

Accepted 03 Dec., 2015

<sup>1</sup>Programa de Pós-graduação em Ciência e Tecnologia de Alimentos, Universidade Federal Rural do Rio de Janeiro – UFRRJ, Seropédica, RJ, Brasil

<sup>2</sup>Faculdade Bezerra de Araújo, Rio de Janeiro, RJ, Brasil

<sup>3</sup>Programa de Pós-graduação em Recursos Naturais da Amazônia, Universidade Federal do Oeste do Pará – UFOPA, Santarém, PA, Brasil

<sup>4</sup>Departamento de Nutrição Básica e Experimental, Universidade Federal do Rio de Janeiro – UFRJ, Rio de Janeiro, RJ, Brasil

\*Corresponding author: alanfbarbosa@yahoo.com.br

## 2 Materials and methods

### 2.1 Plant material

Jambu (whole plant: leaves, fine stems and inflorescences) was sampled in the Municipality of Igarapé-Açu, belonging to the Meso and Micro Northeast Pará, Bragantina Region, Pará state, Brazil, under the coordinates: 01° 07' 33" S and 47° 37' 27" W. The plant (MG205534) was identified as *Acmella oleracea* L. (Asteraceae), and a voucher sample was deposited in the herbarium of Emílio Goeldi Museum, Belém city, Pará state, Brazil.

### 2.2 Drying process

The Jambu was initially washed with water to remove soil residues. Then, the roots and the torn, crumpled and darkened parts of the plant were eliminated. The plant was sanitized for 10 min in a free residual chlorine solution (200 ppm) derived from sodium hypochlorite (10% purity). A second rinse was performed in the same solution (5 ppm) for 10 min, with the subsequent drainage. Finally, the plant was washed before its microbiological analysis. The cold drying process was carried out in a climatized room of 4.0 m<sup>2</sup>, with air-conditioning (Midea, model MS2E-18CR, Brazil), at 25 °C. Also, a dehumidifier (Arsec, model 160, Brazil) was used, and the room remained closed during the drying procedure.

### 2.3 Drying curve

The water streaming was determined by gravimetric method during the drying process, and the periodic weighing (every 30 min) was made in a semi-analytical balance (Filizola, BP15, São Paulo, Brazil), until constant weight. These weighings were performed in triplicate, and the results were expressed on the dry basis. After drying, the dehydrated Jambu was used to determine its dry mass, according to a methodology of the Adolph Lutz Institute (Instituto Adolfo Lutz, 2008). The moisture was expressed on a dry basis (g of water/g of dry solids). The drying curve was generated from the moisture content of Jambu during the drying period, and it has indicated the water content reduction.

### 2.4 Microbiological analysis

For Jambu *in natura* and dried were conducted microbiological analysis with *Salmonella* spp, coagulase-positive *Staphylococcus*, and coliforms, at 45 °C, as described by APHA (American Public Health Association, 2001). These analyses were performed before the sensory analysis to verify that the samples were by the standards of legislation (Brasil, 2001), causing no risk to consumer health.

### 2.5 Sensory evaluation

The acceptance test of Tacacá with Jambu *in natura* and dried was conducted and its marketing potential was evaluated. The study was approved by the Ethics Committee in Research of the Universidade Federal Rural do Rio de Janeiro (COMEP/UFRRJ), Protocol 23083010094/201208, August 9, 2013. Thirty evaluators participated in the sensory analysis,

consisting of untrained consumers for the product, which were selected based on their availability and interest. The effective sensory test, with 9-point hedonic scale, was performed in the sensory analysis laboratory of UFRRJ, at 11 am. The samples were about 50g of Tacacá with Jambu *in natura* and dried, coded with three-digit numbers. These samples were offered in randomized and balanced complete blocks, in a monadic random way (Meilgaard et al., 2006).

To test the performance, the evaluators have received a tray with the samples, the formularies for the test, and a disposable cup with natural water at room temperature, to clean the palate. The form of the effective test consisted of a 9-point hedonic scale, ranging from 1 to 9 (1 – I disliked it very much and 9 – I liked it very much), evaluating the global acceptance, color, aroma, texture, flavor, as well as the consumer profile in terms of gender, age, level of education and the food consumption frequency record. For the attribute “purchase intent”, a 5-point structured scale was applied to 30 untrained evaluators, in which 1 represents the minimum score “I would definitely not buy” and 5 represents the highest score “I would certainly buy”. To calculate the acceptability rate of the product was adopted the expression IA (%) = x 100 A/B, where A = average score obtained for the product and B = maximum score given to the product (Dutcosky, 2013).

The forms for sensory acceptability and intent purchase tests were collected, and the answers were converted into scores (1 to 9 and 1 to 5, respectively). The arithmetic averages of the scores obtained for each product were calculated and subjected to Student t-test at 5% level of significance ( $p > 0.05$ ), using BioStat 5.0 (Ayres et al., 2007). The results were presented as the mean and standard deviation.

## 3 Results and discussion

### 3.1 Drying curve

The drying curve of Jambu at 25 °C can be seen in Figure 1. The total drying time was 44.5 hours.

In the behavior of the drying curve (Figure 1), it was verified that there is no evidence for the presence of a surface moisture

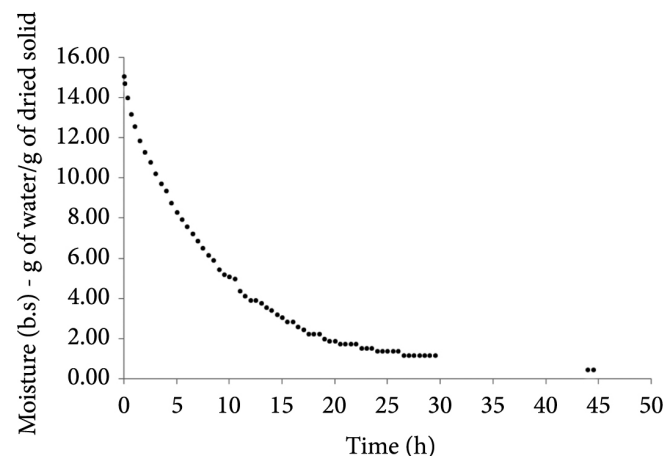


Figure 1. Drying curve of Jambu.

content, but only the internal moisture (Park et al., 2002). For example, in cashew drying and the residual passion fruit fiber, it was also observed a decreasing drying rate (Pena et al., 2008; Azoubel et al., 2009). Oliveira et al. (2014) have obtained a drying curve similar to that found in the present study, when evaluating the drying curve of dry Jambu, in the oven at 45 °C. In that study, during the first hour of drying occurred a sharp drop in moisture content, once the raw material had high humidity. Then, the drying was slower, and it stabilized in the seventh hour with a final moisture content of 8.83% for the dried Jambu. The time required for drying was lower than in this study because the authors used a higher temperature. Comparing the two results, the drying process used by us reached about the same moisture content (10.07%), with the ambient temperature. Thus, with more preservation of the plant material.

### 3.2 Microbiological analysis

The results of the microbiological analysis of the Jambu *in natura* and dried by cold air are showed in Table 1. The presence of *Salmonella* spp was not detected in all the Jambu samples. The coagulase-positive *Staphylococcus* counting was  $<1 \times 10^1$  CFU/g in the dried Jambu, meeting the legislation standards (RDC No. 12/2001), which calls for the maximum score of  $10^2$  (Brasil, 2001). Similarly, the dried Jambu has presented a coliform enumeration  $<3$  MPN/g, at 45 °C, meeting the legislation standards, which accepts a maximum enumeration  $10^3$  MPN/g (Brasil, 2001).

The importance of these results can be seen in the work of Sant'Ana et al. (2011) who have evaluated 512 packages of minimally processed vegetables and observed that four of them showed positive for *Salmonella* spp result. *Salmonella* spp was detected in a packet of lettuce and arugula, and there were *Salmonella* *Typhimurium* and *Salmonella enterica* subsp. *enterica* O:47:z4, z23 serovars, respectively. Organic lettuce and a mix of vegetables (escarole and chicory) presented counts of microorganisms ( $8.8 \times 10^2$  CFU/g, and  $2.4 \times 10^2$  CFU/g, respectively) in the study on enumerations, and the isolates belonged to serovar *S. Typhimurium*, in both samples.

### 3.3 Sensory assessment

The acceptance test was applied to 30 consumers, aged 18-65 years, where 70% were women. The interviewees alleged to consume 90% of leafy vegetables on a weekly basis, 3.3% on a monthly basis and 6.7% rarely consumed. It demonstrated significant consumption trend. Most consumers (46.7%) had completed high school; approximately 46.7% were students of the college and graduate programs, 76.7% of consumers were natural from Pará State; 16.7% from Rio de Janeiro State; 3.33% from Amazonas State; and 3.33% from Ceará State. It is noteworthy that consumers from Rio de Janeiro State were descended from Pará State citizens, which consume regularly Tacacá. The results of the sensory evaluation for some attributes are in Table 2. Namely, these attributes were: global acceptance, color, aroma, texture and the flavor of the Tacacá dishes made with both Jambu *in natura* and dried by cold air.

**Table 1.** Microbiological analysis for the Jambu *in natura* and dried by cold air.

| Jambu            | <i>Salmonella</i> spp<br>25 g | Coagulase-positive<br><i>Staphylococcus</i><br>(CFU/g) | Coliforms<br>(MPN/g)<br>45 °C |
|------------------|-------------------------------|--|-------------------------------|
| <i>In natura</i> | Absent                        | $< 1 \times 10^1$                                      | $< 3$                         |
| Dried            | Absent                        | $< 1 \times 10^1$                                      | $< 3$                         |

**Table 2.** Sensory acceptability of Tacacá made with Jambu *in natura* and dried by cold air.

| Attributes <sup>1</sup> | Tacacá<br>(Jambu, <i>in natura</i> ) | Tacacá<br>(Jambu, dried) |
|-------------------------|--------------------------------------|--------------------------|
| Global acceptance       | $8.67 \pm 0.66^a$                    | $8.00 \pm 1.46^b$        |
| Color                   | $8.27 \pm 0.74^a$                    | $8.00 \pm 0.91^a$        |
| Aroma                   | $7.97 \pm 1.07^a$                    | $7.60 \pm 1.61^a$        |
| Texture                 | $8.27 \pm 0.87^a$                    | $7.63 \pm 1.45^a$        |
| Flavor                  | $8.43 \pm 0.93^a$                    | $8.00 \pm 1.46^a$        |

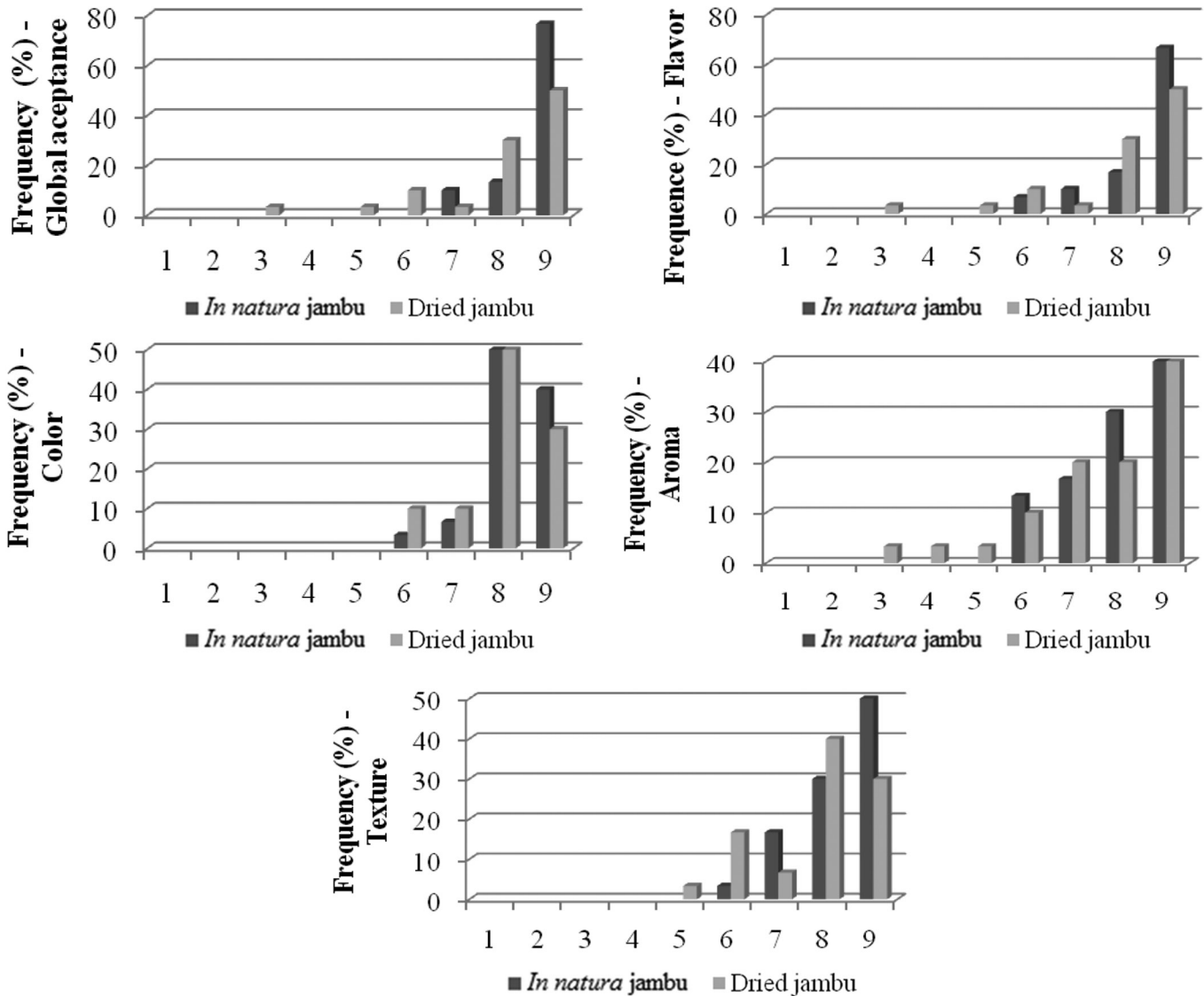
<sup>1</sup>Data expressed as the mean  $\pm$  standard deviation. Different letters between rows indicate significant difference ( $p < 0.05$ ), statistically.

Differences in color between Tacacá samples prepared with Jambu *in natura* and dried was not observed. Scores have indicated the ranges of acceptance between "I enjoyed it" (8.27) and "I liked it very much" (8.00). The aroma scores were 7.97 and 7.60, respectively, with no statistically significant difference ( $p < 0.05$ ). Therefore, the smell of Tacacá was not changed in depending on the used raw material, the Jambu *in natura* or dried. For the flavor of the two treatments, a statistical difference was not observed. However, there was a better acceptance of the Tacacá prepared with the *in natura* Jambu (8.43). Thus, it indicated the acceptance range between "I enjoyed it" and "I liked it very much". In the global acceptance, there was a significant difference (t-test, 5%) between the samples of Tacacá prepared with *in natura* Jambu and those with dried Jambu. The Tacacá with *in natura* Jambu has showed better acceptance in this attribute.

Although there was no significant difference between samples of Tacacá prepared with fresh and dried Jambu, with regard the aroma and flavor attributed to the Tacacá prepared with Jambu *in natura* it has showed greater acceptance by the consumers. The highest mean score of *in natura* Jambu may have occurred during the drying process, due to the loss of volatile substances. Such loss decreases the sensory quality of the product. Ding et al. (2012) evaluated the effect of four drying methods applied to ginger volatiles and observed some losses in its appearance, as well as in the emergence of other substances. These authors concluded that drying through microwaves was the favorite method for losing volatility, followed by drying through hot air circulation (60 °C), vacuum drying, freeze-drying and hot air drying at 50-70 °C.

The frequency distribution of scores obtained by Tacacá prepared with Jambu *in natura* and dried was compared for global acceptance, color, aroma, texture, and flavor. It is showed in Figure 2.

Oliveira et al. (2014) evaluated the sensory acceptability of a garlic paste seasoned with Jambu and they observed that most



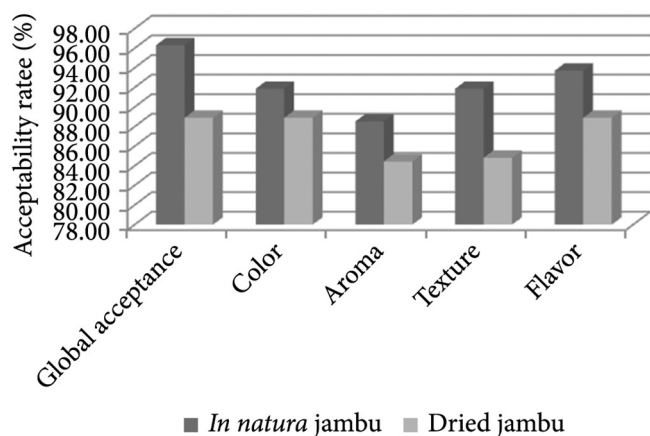
**Figure 2.** Frequency distribution of different sensory attributes evaluated through samples of Tacacá prepared with Jambu *in natura* and dried by cold air: global acceptance, color, aroma, flavor, and texture. 1 (I disliked it very much), 2 (I disliked it too much), 3 (I disliked it moderately), 4 (I disliked it slightly), 5 (I did not like nor disliked it), 6 (I liked it slightly), 7 (I liked it moderately), 8 (I liked it too much), 9 (I liked it very much).

of the tasters (83.7%) evaluated the product as “I liked it very much”. In the present study, 76.67% of the tasters said “I liked it very much” for the tacacá prepared with Jambu *in natura*, and 50% of the tasters said also “I liked it very much” for the Tacacá with dried Jambu.

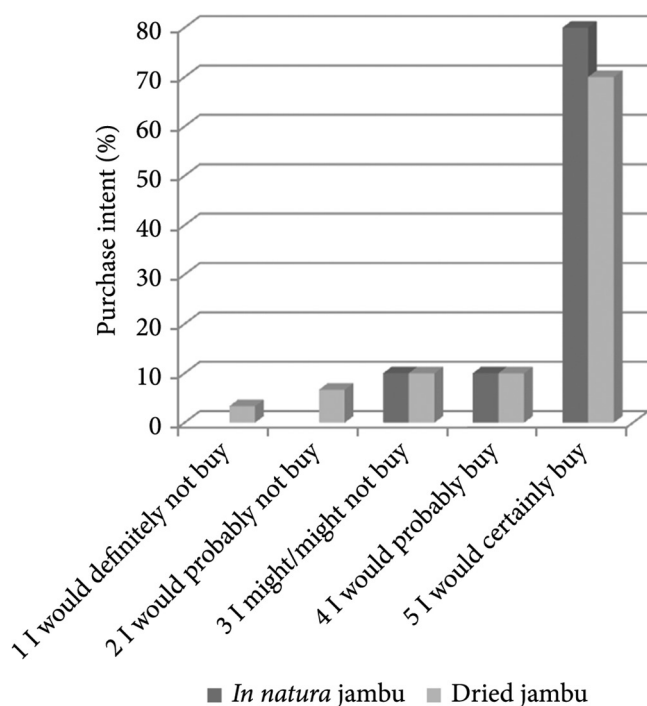
The acceptability rate results for the attributes global acceptance, color, aroma, texture and flavor of the two samples of Tacacá are shown in Figure 3.

The two samples of Tacacá showed acceptability rate above 84% (Figure 3) in all evaluated attributes (global acceptance, color, aroma, texture, and flavor). According to Teixeira et al. (1987), the product is accepted by sensory properties if it shows acceptability rate of at least 70%. Thus, the sensory evaluation performed in the current study showed that the two samples of Tacacá, prepared with Jambu *in natura* and dried, were well accepted, and they have a good commercial potential.

Oliveira & Soares (2012) have assessed the acceptability of dehydrated products (*Ocimum basilicum* L. and *Coriandrum sativum* L.) obtained from widely consumed dry materials in the Amazon and found that garlic paste seasoned with basil, and garlic paste seasoned with coriander showed high acceptance rate, 82.6%, and 77.03%, respectively. These authors observed that only 44% of consumers would buy the product identified as “garlic paste seasoned with basil”. However, for the “garlic paste seasoned with Jambu” (Oliveira et al., 2014), 53% of the tasters responded “I would certainly buy” the product and 27% answered “I would probably buy”. So, 80% of the tasters were interested in purchasing the product, mainly because of the characteristic flavor of Jambu that is highlighted in the garlic paste. These two cited studies (Oliveira & Soares, 2012; Oliveira et al., 2014) have presented percentage of purchase intent (“I would probably buy”) below that found in the current study, which were 90%



**Figure 3.** Acceptability rate of Tacacá prepared with Jambu *in natura* and dried by cold air.



**Figure 4.** Intention to purchase Tacacá prepared with Jambu *in natura* and dried by cold air.

for Tacacá with Jambu *in natura*, and 80% for Tacacá with dried Jambu. See Figure 4.

The average purchase intent was  $4.70 \pm 0.65$  for Tacacá with Jambu *in natura* and  $4.37 \pm 1.13$  for Tacacá with dried Jambu. There was no significant difference (t-test, 5%) regarding the purchase intention of Tacacá with Jambu *in natura* or dried. Therefore, both samples of Tacacá caused the same expectation towards the evaluators. The average purchase intent was  $4.70 \pm 0.65$  for Tacacá with *in natura* Jambu and  $4.37 \pm 1.13$  for Tacacá with dried Jambu. There was no significant difference (t-test, 5%) regarding the purchase intention of Tacacá with Jambu *in natura* or dried. Therefore, both samples of Tacacá caused the same expectation towards the evaluators.

## 4 Conclusion

The Jambu *in natura* and dried by cold air is according the current Brazilian Legislation regarding microbiological aspects. The Tacacá samples prepared with Jambu *in natura* and dried showed good acceptance by consumers. Thus, by taking into account the health and sensory aspects, it is possible stating that the dried Jambu commercialization is viable, since it facilitates its transportation and handling, as well as reduces its vegetable mass.

## Acknowledgements

The authors are grateful to FAPERJ, CNPq, and CAPES for scholarships and financial support.

## References

- American Public Health Association – APHA. (2001). *Compendium of methods for the microbiological examination of foods* (2nd ed.). Washington. 914 p.
- Ayres, M., Ayres JR., M., Ayres, D.L., Santos, A.S. (2007). *BioEstat 5.0: aplicações estatísticas nas áreas das ciências biológicas e médicas*. Manaus: Sociedade Civil Mamirauá/MCT-CNPq.
- Azoubel, P. M., El-Aouar, Â. A., Tonon, R. V., Kurozawa, L. E., Antonio, G. C., Murr, F. E. X., & Park, K. J. (2009). Effect of osmotic dehydration on the drying kinetics and quality of cashew Apple. *International Journal of Food Science & Technology*, 44(5), 980-986. <http://dx.doi.org/10.1111/j.1365-2621.2008.01783.x>.
- Borges, L. S., Vieira, M. A. R., Marques, M. O. M., Vianello, F., & Lima, G. P. P. (2012). Influence of organic and mineral soil fertilization on essential oil of *Spilanthes oleracea* cv. jambuarana. *American Journal of Plant Physiology*, 7(3), 135-142. <http://dx.doi.org/10.3923/ajpp.2012.135.142>.
- Brasil, Ministério da Saúde, Agência Nacional de Vigilância Sanitária – ANVISA. (2001). Resolução RDC nº 12, de 2 de janeiro de 2001. Aprova o Regulamento Técnico sobre os Padrões Microbiológicos para Alimentos. *Diário Oficial da República Federativa do Brasil*.
- Ding, S. H., An, K. J., Zhao, C. P., Li, Y., Guo, Y. H., & Wang, Z. F. (2012). Effect of drying methods on volatiles of Chinese ginger (*Zingiberofficinale* Roscoe). *Food and Bioprocess Processing*, 90(3), 515-524. <http://dx.doi.org/10.1016/j.fbp.2011.10.003>.
- Dutcosky, S. D. (2013). *Análise sensorial de alimentos* (4th ed.). Curitiba: Champagnat. 210 p.
- Instituto Adolfo Lutz – IAL. (2008). *Normas analíticas do Instituto Adolfo Lutz: métodos físico-químicos para análise de alimentos* (4th ed.). São Paulo: IAL. 1020 p.
- Isaac, V., Chiari, B. G., Magnani, C., & Corrêa, M. A. (2012). Análise sensorial como ferramenta útil no desenvolvimento de cosméticos. *Revista de Ciências Farmacêuticas Básica e Aplicada*, 33(4), 479-488.
- Kubota, E. H., & Cal-Vidal, J. (1987). Secagem a frio de um produto lácteo. *Revista do Instituto de Laticínios Cândido Tostes*, 42(253), 35-42.
- Lim, J. (2011). Hedonic scaling: a review of methods and theory. *Food Quality and Preference*, 22, 733-747.
- Meilgaard, M., Civille, G. V., & Carr, B. T. (2006). *Sensory evaluation techniques*. Boca Raton: CRC. 416 p.
- Nascimento, A. M., Souza, L. M., Baggio, C. H., Werner, M. F. P., Maria-Ferreira, D., Silva, L. M., Sassaki, G. L., Gorin, P. A. J., Iacomini, M., & Cipriani, T. R. (2013). Gastroprotective effect and structure of a rhamnolacturonan from *Acmella oleracea*. *Phytochemistry*,

- 85(1), 137-142. <http://dx.doi.org/10.1016/j.phytochem.2012.08.024>. PMID:23014505.
- Oliveira, D. C. R., Soares, E. K. B., Fernandes, H. R., & Brasil, L. S. N. S. (2014). Elaboração e caracterização físico-química, microbiológica e sensorial de pasta de alho condimentada com jambú (*Spilantes oleraceae* L.) desidratado. *Scientia Plena*, 10(1), 1-8.
- Oliveira, D. C. R., & Soares, E. K. B. (2012). Elaboração e caracterização físico-química, microbiológica e sensorial de produtos desidratados obtidos a partir de matérias-primas amplamente consumidas na Amazônia. *Scientia Plena*, 8(5), 1-7.
- Park, K. J., Bin, A., & Brod, F. P. R. (2002). Drying of pear d'Anjou with and without osmotic dehydration. *Journal of Food Engineering*, 56(1), 97-103. [http://dx.doi.org/10.1016/S0260-8774\(02\)00152-8](http://dx.doi.org/10.1016/S0260-8774(02)00152-8).
- Pena, R. S., Silva, D. M. S., Mendonça, N. B., & Almeida, M. D. C. (2008). Estudo da secagem da fibra residual do maracujá. *Revista Brasileira de Tecnologia Agroindustrial*, 2(1), 1-13. <http://dx.doi.org/10.3895/S1981-36862008000100001>.
- Sant'Ana, A. S., Landgraf, M., Destro, M. T., & Franco, B. D. G. M. (2011). Prevalence and counts of *Salmonella* spp. in minimally processed vegetables in São Paulo, Brazil. *Food Microbiology*, 28(6), 1235-1237. <http://dx.doi.org/10.1016/j.fm.2011.04.002>. PMID:21645825.
- Teixeira, E., Meinert, E. M., & Barbetta, P. A. (1987). *Análise sensorial de alimentos*. Florianópolis: UFSC. 182 p.
- Teixeira, L.V. (2009). Análise sensorial na indústria de alimentos. *Revista do Instituto de Laticínios Cândido Tostes*, 64(366), 12-21.