# Influence of Ethanol on Pineapple Kinetics Drying

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## ABSTRACT

With the purpose of verifying the influence of ethanol on drying kinetics of pineapple (*Smooth Cayenne*), drying experiments were performed in a lab scale tunnel dryer with a data acquisition system, which continuously monitors the sample weight and also controls the drying gas temperature. This tunnel allows changing the drying atmosphere by the addition of gases or liquids. For comparison, drying experiments were carried out at 60°C and air velocity of 0.84 m/s under normal air composition (without any ethanol addition), in atmosphere modified by ethanol (0.5% v/v) and normal air composition with the slice surface previously treated with ethanol. Comparing the results, it was evident the influence of ethanol on drying kinetics. Using ethanol in atmosphere or in pineapple surface, shorter drying times were achieved.

**Keywords:** Drying, pineapple, ethanol, modified atmosphere, Brazil.

## 1. INTRODUCTION

Pineapple (*Ananas comosus* L. Merr) is a tropical fruit from Ananas ananas plant. It is originated from the american continent and can be found from Central America to North of Argentina. The pineapple is notable by its exotic flavor as well as its high energy content due to the sugar composition and nutritional value by the presence of minerals (calcium, phosphorus, magnesium, potassium, sodium, copper, iodine) and vitamins (C, A, B1, B2 and Niacin). Its annual production exceeds 19 billion tonnes and, according to FAO (2007), Brazil is the second most producer of pineapple in the world and the production has been growing year after year. Despite this increasing availability, not all the pineapple production is well used for consumption. It is known that the seasonal nature of fruits and vegetable production, the poor conditions of storage and the lack of information on a suitable processing technology are the reasons that inhibit the full enjoyment of fruits (Azoubel et al., 2009).

Air drying is an ancient process used to preserve foods in which the solid to be dried is exposed to a continuously flowing hot stream of air where moisture evaporates. In the last few years, the market of dried fruits has presented great increase, particularly because of the search for healthier foods by the consumers. Dried fruits present a higher nutrient density and fiber content, longer shelf life, and significantly higher phenol antioxidant content compared to fresh fruits (Vinson et al., 2005). Moreover, the availability throughout the year, the practical use, reduced perishability and volume to be transported facilitate the dried fruits exportation (Belghit et al.

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2000). However, during drying, the exposition of fruits and vegetables for a long period of time to high temperature, generally lead to undesirable changes in the quality attributes of these materials, like darkening, loss of rehydration ability, shrinkage and loss of aroma. Currently, technologies have been developed in order to diminish drying time, reducing energy costs and obtaining better products at the same time. This is reached using new methods, improving and optimizing the existing ones, in order to maximize the quality attributes.

Some studies have been developed aiming to keep the properties in some fresh fruits and vegetables after drying processes. The modification of drying atmosphere with nitrogen was used for retention of 6-gingerol during ginger drying, (Hawlader et al., 2006a) and also improved the properties (color, porosity, and ability of rehydration) of dried apple, guava, and potato (Hawlader et al., 2006b). Heat pump dryers operating with nitrogen or $CO_2$ provided dried products (guava and papaya) with less browning, faster dehydration, and enhanced vitamin C retention (Hawlader et al., 2006c).

Despite ethanol presents great desiccant properties, only few works have been developed considering its application as a possible improvement on drying processes. In a previous study, vapor of ethanol was added to the drying air in order to improve the color of wood (Pang, 2006). Using a lab-scale tunnel dryer in which the drying atmosphere can be modified by liquid or gas addition, the modification of the drying atmosphere with ethanol vapor (0.5% v/v) promoted a more intense evaporation of water, as well as greater retention of volatile compounds in pineapple samples. (Braga et al., 2009)

To verify the influence of ethanol on drying kinetics of pineapple (*Smooth Cayenne*), air drying experiments were performed in a tunnel dryer under normal air composition (without any ethanol addition), in atmosphere modified by ethanol (0.5% v/v) and normal air composition with the slice surface previously treated with ethanol.

## 2. MATERIALS AND METHODS

### 2.1 Sample Preparation

Smooth Cayenne pineapples (*Ananas comosus* L. Merr), with the same maturation degree, which corresponded to moisture content 82 to 85% (wet basis), soluble solids content, 12 to 14ºBrix and the peel fruit half green half yellow, were purchased at the local market (Campinas, SP, Brazil). The fruits were peeled and transversally cut into slices of 10 cm diameter and 0.5 cm thickness with a circular stainless steel cutter and cored.

### 2.2 Drying Conditions

In this experimental study, a tunnel dryer made of polycarbonate, with 1.70 m length and 0.07 $m^2$ cross sectional area was used. This tunnel allows the changing of drying atmosphere by the addition of gases or liquids. The tunnel is composed of blower, heater, gas flow equalizers, sample holder and an electronic scale, a programmable logical controller and the data acquisition system, which continuously controlled mass and temperature during experiments. The atmosphere composition was modified by the addition of ethanol, which was atomized by a double-fluid peak atomizer (Spraying Systems Co®) using an atomization pressure of 73.5 $kN/m^2$, in order to achieve a gaseous ethanol concentration of 0.5 % (v/v). The experimental set-up was fully described by Morais and Silva (2004). For comparison, drying experiments were carried out at 60°C and air velocity of 0.84 m/s under normal air composition (without any ethanol addition), in atmosphere modified by ethanol (0.5% v/v) and normal air composition with the slice surface previously treated with 5 ml ethanol. The conditions used in the drying experiments are summarized in Table 1.

Table 1. Experimental conditions for pineapple drying

| *Test* | *Temperature (°C)* | *Air velocity (m/s)* | *Drying atmosphere* | *Pineapple surface treatment* |
|---|---|---|---|---|
| 1 | 60 | 0.84 | Normal | - |
| 2 | 60 | 0.84 | Ethanol 0.5% (v/v) | - |
| 3 | 60 | 0.84 | Normal | 5 ml ethanol |

The drying rates were calculated by the derivation of the drying curves by the software Origin 6.0.

## 3. RESULTS AND DISCUSSION

### 3.1 Drying experiments

As showed in Table 1, three experiments were realized. Figure 1 shows the drying curves for these experiments. It is clearly observed that using ethanol on pineapple surface it was found that the moisture evaporated faster than in normal air and also under modified atmosphere. Previously studies showed that drying under modified atmosphere with ethanol 0.5 % (v/v) provides faster evaporation, comparing with drying under normal atmosphere (Braga et al., 2009). Probably during drying under modified atmosphere, ethanol was condensate on pineapple surface, accelerating the process, as already cited by Schultz and Schlünder (1980). The curves show that, when treating the slice surface with ethanol, the evaporation of water was even faster. To achieve the same moisture less drying time was needed, comparing the processes carried out both in modified and in normal atmospheres without pretreatment with ethanol.

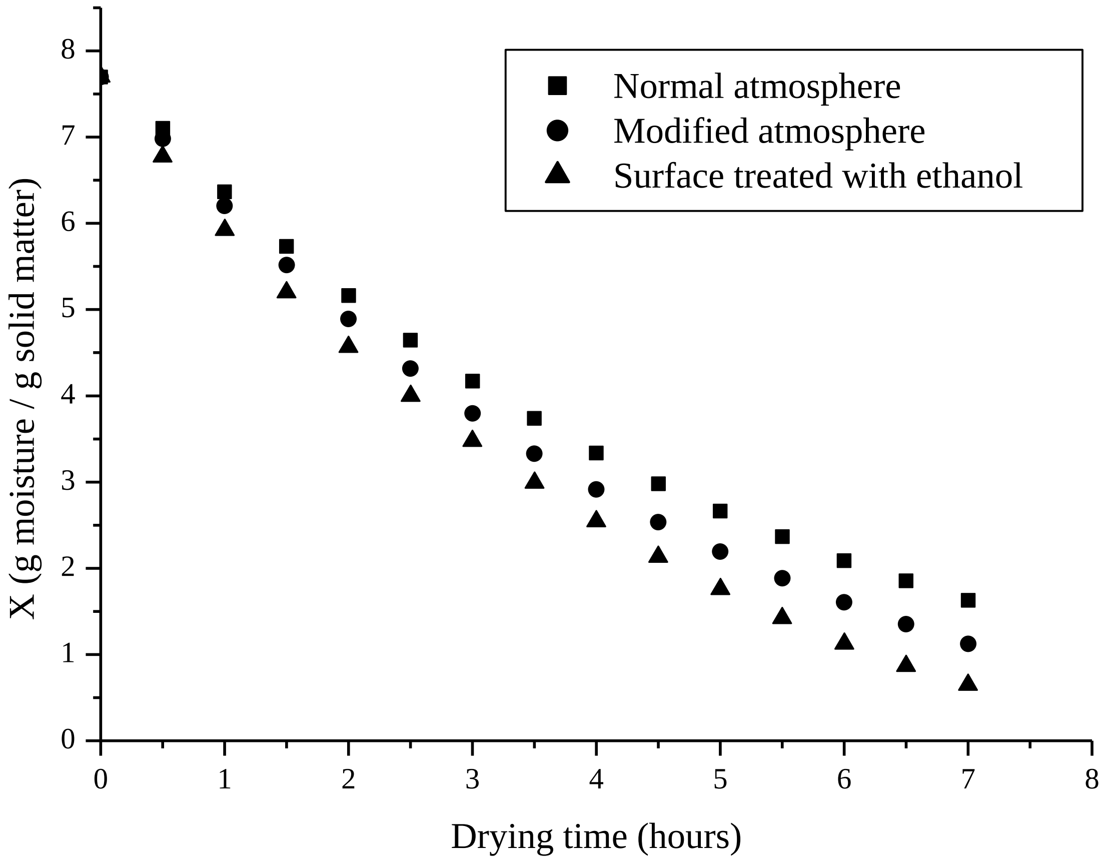


Figure 1. Experimental drying curves of *Smooth Cayenne* pineapple under different conditions.

The drying rates presented on Figure 2 confirm the great influence of ethanol on drying kinetics. Comparing the curves, it is evident that using ethanol in atmosphere or in pineapple surface, higher drying rates were achieved. And this difference is observed mainly at the first hour of drying. After that, the presence of ethanol showed minor impact on water evaporation. Observing the three conditions in the first hour of drying, the curves show a slope quite different from that displayed during the remainder of the process. Possibly, if the shrinkage was considered, when calculating the drying flux, it could be observed a constant period during this initial time. For foodstuffs which present a high initial moisture content and therefore having high tendency to shrink, the calculation of drying rates must incorporate the shrinkage factor for it. (May and Perré, 2002). During this study, the surface area suffered a considered reduction, but it was not counted on drying rates calculation. Further studies computing the shrinkage will be realized so as to show the reality.

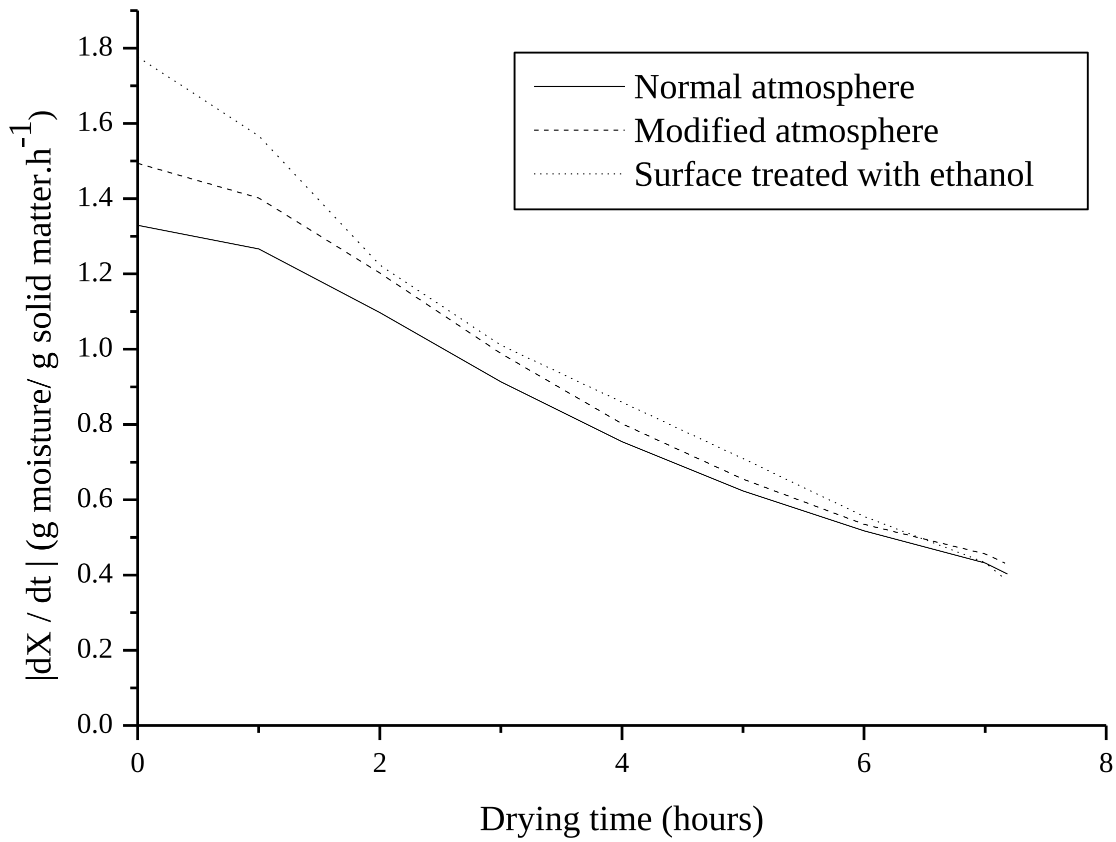


Figure 2. Drying rates of pineapple samples dried in different conditions.

## 4. CONCLUSIONS

This preliminary study showed the great influence of ethanol on drying kinetics. Shorter drying times were achieved using ethanol, either in air or on the slice surface of pineapple. Moreover, the drying rate curves showed that the impact of ethanol is much higher in the early hours of drying. Further studies should be made in order to determine the slice shrinkage during the process to verify if a constant rate period in fact occurs.

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