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Inventory and comparative characteristics of dryers used in the sub-Saharan zone: Criteria influencing dryer choice



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ABSTRACT

A survey was carried out in Togo, Benin and Burkina Faso involving 140 respondents and three climatic zones. Ten typical types of dryers with batch operating and natural convection were inventoried. Analysis of the results showed that: (1) Traditional sun dryers were widely used everywhere from 1 to 4000 kg per cycle, costing €0 to €7.63 per m² drying area. (2) Low power solar dryers were mostly used in the Sahel and Sudan-Sahel tropical climate, from 5 to 1000 kg, costing from €9.11 to €238.55 per m² of tray. (3) Gas dryers were used in all climatic zones at around 100 kg per cycle, with a high drying power, costing from €107.52 to €181.75 per m² of tray. The acquisition of dryers depended mostly on the distance between provider and user and on the means of dissemination.

A thermo-economic analysis was carried out to determine which dryers were most successfully adopted. These dryers will be re-employed by the users when the investment and maintenance costs enable profit to be made from the drying operation. Two types of dryers met those conditions: the traditional simple sun dryer used by families and groups: a study of an application on maize showed costs of €0.01/kg of evaporated water equal to 7% of daily capital gain; the Atesta gas dryer used by small and medium-sized enterprises: applied to pineapple, cost €0.07/kg of evaporated water equal to 9% of daily capital gain. New criteria had to be added to all those listed from the literature in order to choose a dryer properly: characteristics of the product to be dried, product added value, local energy availability and cost, labour skills and availability, local material availability and user investment capacity.

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1. Introduction

Drying is a significant activity in the food production chain. Drying processes are far less advanced in developing countries than in western countries. They are often used for food preservation to avoid product losses [1]. Many food products are dried in rural and urban areas for both local consumption and export [2].

Over the past 30 years, many studies have been carried out on tropical food drying and dryers for and in developing countries (Asia, Africa or South America) [2,3]. Many of those studies focused on improving the dryer thermal efficiency and less on the product quality. Very few were concerned with technology innovation dedicated to decreasing the costs of drying [4–9]. It is important to note that: most food products are still exposed to the sun for natural solar drying (sun drying) and most dryers developed either by academics or manufacturers meet low commercial success.

The literature on the classification of dryers, on an industrial scale, is abundant [10–12]. On a craft scale and for agricultural applications, Ekechukwu and Norton [13], Murphy [14], Sharma et al. [2] and Fudholi et al. [6] proposed recent reviews on classifications of solar dryers mainly based on scientific literature.

The choice or the design of a dryer adapted to a specific need remains a major issue [10,15]. According to a survey involving 14 European Chemical Companies [10], “over ninety percent of the companies had made errors in the selection of their new dryers”. In the literature, the dryer specification criteria are different from one author to another, which makes it difficult to compare them [14,16]. Most studies and reviews on food product dryers do not mention the areas or countries surveyed. In a developing country context, Marouzé and Giroux [17], Desmorieux and Idriss [18] showed from field studies that most food processing equipment,

including dryers, does not integrate a preliminary study of user requirements. For those authors and for Mujumdar [10], a more appropriate dryer selection involves the identification of the dryer user’s needs together with the characterization of the existing dryers. Consequently, choosing a dryer should take into account the user needs as well as the end use of the dried product, which are two criteria rarely mentioned in existing scientific literature. To that end, in order to more effectively reflect reality in the field, this work was positioned at the interface among several domains: the technical efficiency of dryers, process engineering and socio-economic reality.

This article reports on and analyses the results of a survey on drying equipment for small- and medium-scale use in three West African countries, Togo, Benin and Burkina-Faso.

Initially, to characterize and class the dryers listed, a review of the literature was undertaken to gather all the criteria considered to qualify dryers. They were numerous and varied depending on the studies reviewed. They can be grouped into five classes: specifications of the dryers, specifications of the products, energy and mass balance aspects, specifications of the environment including the users and economic aspects. The survey revealed that not all the criteria were sufficient for taking into account the environmental context or for understanding why energy-efficient dryers, according to the literature, were not adopted in the field. The study therefore proposes some new criteria.

Not all the criteria from the literature could be used to describe the dryers listed, because the existing criteria were not all adapted to the developing countries situations in our study. The dryers listed are all classed into 10 typical types, they were characterized with the data collected from the survey, some criteria from the

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