Contents lists available at ScienceDirect

Food and Bioproducts Processing

journal homepage: www.elsevier.com/locate/fbp

Physicochemical and sorption isotherm properties of date syrup powder: Antiplasticizing effect of maltodextrin

Asgar Farahnaky[a,b,*], *Nasim Mansoori*[b], *Mahsa Majzoobi*[a,b], *Fojan Badii*[c]

[a] *School of Biomedical Sciences, Graham Centre for Agricultural Innovation and ARC Industrial Transformation Training Centre for Functional Grains, Charles Sturt University, Wagga Wagga, NSW, Australia*
[b] *Department of Food Science and Technology, School of Agriculture, Shiraz University, Shiraz, Iran*
[c] *Department of Food Engineering and Postharvest Technology, Agricultural Engineering Research Institute, Karaj 31585-845, Iran*

ARTICLE INFO

Article history:
Received 13 June 2015
Received in revised form 20 October 2015
Accepted 4 January 2016
Available online 12 January 2016

Keywords:
Date syrup powder
Maltodextrin
Sorption isotherm
Caking
Glass transition

ABSTRACT

In this research, date syrup powder was produced using a twin drum dryer. Maltodextrin with dextrose equivalent of 19, as an antiplasticizer, was added to date syrup at various concentrations (30, 40, 50 and 60%, dry basis of date syrup) to improve its drying properties. Some physicochemical properties of the powders including degree of caking, density, color, glass transition temperature and sorption isotherms were studied and compared. Powder density, lightness and glass transition temperature increased with maltodextrin level. However, "*a*" color value and degree of caking decreased as maltodextrin increased. Moisture sorption isotherms were obtained at 5–60 °C and the data were modeled to BET, GAB, and Peleg models and GAB and Peleg were found as suitable models to fit moisture sorption data. Monolayer moisture content decreased with maltodextrin level from 0 to 60% as calculated from BET and GAB models. All date syrup powders showed type III isotherms similar to that of high-sugar foods. Maltodextrin acted as antiplasticizer in date syrup drying and date syrup powder of low caking property was produced successfully.

1. Introduction

Total world production of 6.4 million tons has been reported in 2007 and date fruit is an important element in economy of date growing countries. Date flesh is rich in sugars mainly fructose and glucose but is low in fat and protein (Al-Farsi and Lee, 2008). Most of date sugar is in the form of simple sugars that the human body can easily absorb (Ahmed and Ahmed, 1995). Date is a good source of many minerals such as potassium, phosphorous, magnesium, sodium, iron and calcium (Prior and Cao, 2000). Date fruit also contains high amounts of antioxidants which are well known to have fundamental roles, in the prevention of cancers, cardiovascular disease, neurodegenerative diseases, such as Parkinson and Alzheimer diseases (Dragsted et al., 1993; Renaud and DeLorgeril, 1992; Fuhrman et al., 1995; Okuda et al., 1992).

Due to biological and physical characteristics of different types of date fruits, and environmental impacts of growing regions, large quantities of the produced dates do not meet the minimum quality attributes for direct use. Fruit size, physical defects or damages during harvesting and processing are among the main reasons for quality deteriorations. Therefore, low and medium quality dates that are not directly consumed by human have been used as raw materials of fermentation

* *Corresponding author*. Tel.: +61 269332339; fax: +61 269332587.
E-mail address: afarahnaky@csu.edu.au (A. Farahnaky).
http://dx.doi.org/10.1016/j.fbp.2016.01.003
0960-3085/

industry or animal feed for many years and are considered as low price.

In the recent years innovative date by-product processings are being developed aiming at producing value added products of higher quality and value. In this regard, production of high nutritional quality sweeteners from date by-products for sucrose substitution in food formulations is a prime target. Different unit operations are being used for processing of low price dates into new products and as a result a number of final products have been developed and marketed recently. Nowadays continuous production lines are operating to produce a wide number of date products of commercial value including date syrup, date concentrate and date liquid sugar. These liquid date products can be used directly by consumers or food producing factories as semi-finished products in producing different foods such as cake, biscuit and canned foods as sweeteners or replacements for granular sucrose. However, all these date by-products are in liquid state with different physical properties to sucrose. In comparison with granular powdery state of sucrose, the application of date liquid by-products in food production faces major difficulties. These are due to the high viscous liquid like state of date by-products causing operational and technological challenges for their packaging, transport, handling, piping and mixing with other ingredients. Moreover, the inclusion of high viscous date by-products into cake batter and biscuit dough is likely to change dough development, network formation and final product quality (Ahmadi et al., 2001). Drying of fruit juices produces a stable, easy-handling form of the juice that reconstitutes rapidly to a good quality product resembling the original juice as close as possible. Dried juice products are used mainly as convenience foods and have long storage shelf life at ordinary temperatures (Gabas et al., 2007). One of the challenges of producing fruit powders is the reduction of their stickiness to improve drying, handling and storage of fruit powders. The stickiness in fruit powders is mainly due to the presence of low molecular weight sugars, such as fructose, glucose, sucrose and some organic acids in the fruits. The date liquid products are also comprised of these sugars. These sugars and organic acids are very hygroscopic in their amorphous state and have low glass transition temperatures (Sablani et al., 2008). To overcome this undesirable situation, the use of different high molecular weight substances, such as maltodextrin with different dextrose equivalents (DE) and gum Arabic have been indicated, in order to increase glass transition temperature, reduce stickiness and produce free flowing powders with improved handling and quality properties (Mosquera et al., 2012).

Maltodextrins consist of β-D-glucose units linked mainly by glycosidic bonds ($1 \rightarrow 4$) and are usually classified according to their dextrose equivalency (*DE*). The *DE* of a maltodextrin determines its reducing capacity and is inversely related to its average molecular weight (Bemiller and Whistler, 1996). Maltodextrins are mainly used in materials that are difficult to dry such as fruit juices, flavorings, and sweeteners, to reduce stickiness and agglomeration problems during storage, thereby improving product stability (Reineccius, 1991; Bhandari et al., 1993).

It is generally accepted that water activity (a_w) is more closely related to physical, chemical and biological properties of foods and other natural products than the total moisture content. Specific changes in color, aroma, flavor, texture, stability and acceptability of raw and processed foods have been associated with relatively narrow water activity ranges (Rockland, 1969). Water vapour sorption isotherms describe the relationship between water content and water activity. The knowledge of moisture sorption characteristics of products would allow correctly specifying the conditions of storage and packaging, predicting shelf life and understanding the physicochemical changes involved in products manufacturing processes (Tunc and Duman, 2007). Numerous mathematical models have been proposed for description of food moisture sorption behaviors. Some of these models are based on theories of the sorption mechanism; others are purely empirical or semi-empirical. In general, these models can be divided into several categories: kinetic models based on a monolayer (BET model), kinetic models based on a multilayer and condensed film (Guggenheim–Anderson–de Boer (GAB) model), semi-empirical (Ferro-Fontan, Henderson, and Halsey models), and empirical models (Smith, Peleg and Oswin models). The BET model represents a fundamental milestone in the interpretation of multilayer sorption isotherms, particularly for types II and III (Timmermann, 1989). The GAB model is considered to be the most versatile sorption isotherm model available in the literature and for this reason has been adopted by a group of European food researchers COST 90 (Bizot, 1983). More recently, Peleg proposed a four-parameter model for $a_w < 0.9$. This model fits satisfactorily published sigmoidal food isotherms. The monolayer water content is valuable additional information that can be obtained from isothermal data determined from BET and GAB models, while the net isosteric heat can be determined from the Clausius–Clapeyron relationship. The monolayer water content gives information about the minimal water content conferring food stability, while the isosteric heat of sorption is a measurement of the energy or intermolecular bonding between water molecules and adsorbing surfaces (Mulet et al., 1999). Water sorption isotherms of high sugar fruits such as dried apricots, figs, raisins, and prunes have been determined by other investigators (Ayranci and Duman, 2005; Maroulis et al., 1988; Saravacos et al., 1986; Tsami et al., 1990). The criteria used to select the most appropriate sorption model are the degree of fitting to experimental data and the physical meaning of the model.

Kabkab date is one of the main Iranian date varieties, of which only about 35% of its production is used for direct consumptions, and the rest being of low quality is further processed to date liquid by-products or used for animal feed (Entezari et al., 2004). Therefore, the aim of this research was to produce a date syrup powder from Kabkab date syrup with the aid of a compatible antiplasticizer, maltodextrin, and to determine some physicochemical properties and sorption isotherms of the resulting date syrup powder at 5–60 °C.

2. Materials and methods

2.1. *Materials*

Date syrup (from dates variety Kabkab) produced in large industrial scale was purchased from the local market in Bushehr (Bushehr province, southern Iran). Based on manufacturer's information, date syrup was produced industrially with the following production steps: date rehydration with water, heating and mixing, pit and pulp separation and evaporation. Maltodextrin with a dextrose equivalent (*DE*) of 19, produced from wheat starch, was purchased from Luzhou BioChem Technology (Shndong Co., China) and used as an antiplasticizer. Low DE maltodextrins would make dissolving