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STUDIES ON THE EQUILIBRIUM RELATIVE HUMIDITY AND MOISTURE SORPTION ISOTHERM OF MANGO, GUAVA AND MULBERRY FRUIT POWDERS

F.M. KHAN, ABDUL JABBAR AND EIJAZUDDIN

PCSIR Laboratories, Jamrud Road, P.O. Peshawar University, Peshawar 25120, Pakistan

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Reasonably good quality fruit powders from mango, guava and mulberry fruits prepared by hot air drying technique were subjected to ERH investigations. The initial moisture content of these dehydrated products were 2.0, 1.8 and 4.0 %, respectively. The euqilibrium moisture content for quality retention were estimated as 1.54, 1.62 and 3.80% respectively and the corresponding optimum euqilibrium relative humidities for these products were in the rang eof 51.4-71.4, 40.0-51.4 and 22.0-40.0 respectively. The standard humidity conditions, to which the products were exposed, ranged from 11.0 to 92.0%. Mold-growth appeared after 28, 21 and 15 days respectively in mango, guava and mulberry when placed under 92% humidity, whereas under 79.2% ERH, the first mold growth in these products was observed after 40, 32 and 25 days respectively. These studies indicated that the optimum ERH for maintianing good conditions of flow-ability, colour and other physical characteristics was around 51.4% for mango and guava but mulberry powder required more depressed condition of ERH values i.e. 22.0% for maintaining good quality characteristics during the storage.

Key words. Fruit powders, Moisture sorption isotherm, Equilibrium relative humidity.

Introduction

Equilibrium Relative Humidity (ERH), the storage relative humidity at which the product neither gains nor loses moisture, is of utmost importance from the point of view of understanding the storage behaviour of dehydrated products and in determining the design of suitable safe pakages for it. The quality as well aas stability of such products are known to be greatly influenced by moisture sorption characteristics [1-13]. The ERH in turn is influenced considerably by the original moisutre content of the dehydrated product itself. The humidity moisture relationship or sorption isotherm shows the equilibrium relationship between the moisture content of the product and the relative humidity of the atmpsphere immediately surrounding it. According to Taylor [1] the ERH of food material determines whether it will gain or lose moisture in a particular environment and that this property is more relevant to the storage behaviour of dehydrated food products than is the moisture content itself, as it can lead to predict its quality, stability and consequently the shelf life [14]. With this in mind, several researchers have investigated moisture sorption isotherms/ERH of different food products. They employed various techniques viz direct measurement with electric hydrometers [14-16], mathematical formulae [17,14], the weight equilibrium method [18} and the graphical interpolation method [19]. Siddappa and Nan Jundaswamy [20] compared the graphical interpolation and weight equilibrium methods and found that the latter gave more precise data and was, hence, perferrable.

In an attempt to develop instant natural fruit powders, dehydrated juices of vairous indigenous fruits like mango, guava and mulberry were produced in our laboratories. It was observed [21] that initially reasonably good quality products were obtained but that due to the highly hygroscopic nature of the dry products (packed in ordinary glass sample bottles), serious difficulties occurred during storage which adversely affected their quality and shelf life at ambient atmospheric conditions. Therefore, detailed study on the measurement of their humidity moisture relationship or ERH was carried out in order to develop suitable packaging and storage conditions for enhancing stability and consequently the shelf life of these products.

Materials and Methods

The dehydrated fruit powders, as reported earlier [21], were prepared by the standardized hot air drying technique. The moisture contents of mango, guava and mulberry powders were determined by AOAC method No.22.013 [22]. For determination of ERH and equilibrium moisture content, the Winks weight equilibrium method [18] was generally followed. Several powdered dehydrated samples of one gram of each fruit were accurately weighed in a watch glass and three samples (one of each fruit) were exposed to standard relative humidity in separate closed desiccators containing a saturated solution of an appropriate salt. Seven desicators with different salts having standard ERH values ranging from 11.2 to 92% were empolyed. The gain or loss in weight was determined and recorded regularly until the weight of the sample remained constant in three consecutive measuements or when fungal growth appeared, whichever was earlier. Apart from recording gain or loss of weight, visible changes such as loss of colour, texture, physical state and appearance of mold growth etc. if any, were also closely followed and recorded immediately.

Results and Discussion

Data on the relationship between equilibrium moisture content, number of days the product required to reach the equilibrium under varying relative humidity conditions and the physical appearance etc. of mango, guava and mulberry fruit powders are shown in Table 1,2 and 3 respectively. The sorption isotherm curves for these products are shown in Figure 1. Initially the dehydratd products viz mango and guava and mulberry, contain 1.90, 2.0 and 4.0% moisture, respectively. As shown in Table 1 and 2, both mango and guava powders, with initial moisutre content very close to each other, require 13-18 days to reach the equilibrium moisture content under relative humidity values ranging from 11.2 to 71.4%. Above 71.4% ERH, however, the equilibrium is never established and the product absorbs moisture profusely resulting in compact mass formation. In the mango sample, mold growth is noticeable under ERH values of 92% and 79.6% after 28 and 40 days, respectively. For guava, it is observed after 21 and 32 days while in mulberry, it appears at after 15 and 25 days, respectively, under the above mentioned ERH values, indicating the high hygroscopicity of mulberry as compared to mango and guava.

Considering the physical appearance, flow ability and colour as the standards of quality, it can be inferred from Table 1 that for mango the appopriate ERH lies in the range of 51.4-71.8% which is in agreement with the reported values of 64-68% for mango toffee [23]. Fo guava powder, it appears (Table 2) to be in the range of 40-51.4%. Of course, below these values of ERH, the product loses moisture still further in all the three fruits but the range of this loss is rather narrow. The period equired to reach the equilibrium moisture content in all the three produts is geneally found to decrase with the reduction in the ERH values (Table 1,2,3), but it rises again when tghe ERH values are redued to very low levels i.e. 11.2%. Similar obsevations have been reported by Bhattia and Amin [24] for dehydrated fruits and by Muhammad *et al.* [3] fo dehydrated garlic powder.

The sorption isotherms (Fig. 1) fo all the three fruit products depict typical sigmoid cuves. As can be seen (Fig. 1), the mango and guava fruit powders exhibit a sharp rise after about 51.4% relative humidity. It is generally recognized that the beginning of a steep rise in an isotherm is an indicationof the onset of rapid physico-chemical deterioration in a product [25]. In the light of this observation, it can be said that in both mango and guava powders, moisture content of 1.5% and 2% respectively (which corresponds to the ERH values of around 50%) is the critical moisture level for their storage stability. In case of mulberry powder, however, the steep rise in the isotherm is visible at around 2% moisutre content which corresponds to ERH of about 10%. Hence it can be said that the product, being highly hygroscopic, abosrbs moisture in

TABLE 1. RELATIONSHIP OF HUMIDITY WITH EQUILIBRIUM MOISTURE CONTENT, TIME REQUIRED TO REACH EQUILIBRIUM, PHYSICAL CONDITIONS AND APPEARANCE OF MANGO POWDER* EXPOSED TO VARIOUS RELATIVE HUMIDITIES

Salt used	Relative humidity	Days required for equilibrium	Equilibrium moisture content(%) MFB**	Physical conditions
Ammonium dihydrogen phosphate	92.0	--	--	Flow reduced, got moist, mold started after 28 daus
Ammonium sulphate	79.6	--	--	Flow reduced, got moist, mold started after 40 days
Sodium acetate	71.4	18	2.33	Appearance good, free flowing
Magnesium nitrate	51.4	15	1.54	Appearance excellent, free flowing
Chromium trioxide	40.0	15	1.37	Appearance excellent, free flowing
Potassium acetate	22.0	13	1.03	Appearance excellent, free flowing
Lithium chloride	11.2	18	0.82	Appearance excellent, free flowing

* Intial moisture content = 1.9 percent **MFB=Moisture free basis

TABLE 2. RELATIONSHIP OF HUMIDITY WITH EQUILIBRIUM MOISTURE CONTENT, TIME REQUIRED TO REACH EQUILIBRIUM, PHYSICAL CONDITIONS AND APPEARANCE OF GUAVA POWDER* EXPOSED TO VARIOUS RELATIVE HUMIDITIES

Salt used	Relative humidity	Days required for equilibrium	Equilibrium moisture content(%) MFB**	Physical conditions
Ammonium dihydrogen phosphate	92.0	--	--	Flow reduced, got moist, mold started after 21 daus
Ammonium sulphate	79.6	--	--	Flow reduced, got moist, mold started after 32 days
Sodium acetate	71.4	18	2.54	Flow reduced, colour changed
Magnesium nitrate	51.4	15	2.07	Appearance good, free flowing
Chromium trioxide	40.0	15	1.82	Appearance excellent, free flowing
Potassium acetate	22.0	13	1.67	Appearance excellent, free flowing
Lithium chloride	11.2	18	1.24	Appearance excellent, free flowin

* Intial moisture content = 2.0 percent **MFB=Moisture free basis.

relative humidity as low as 10% and that theoptimum moisture and the relative humidity conditions for the product lie below 2.0% and 10% respectively, a condition rather difficult to maintian. It can be, therefore, concluded form these studies that mango and guava powders, having an optimum moisture content of less than 2.0% and ERH of around 50%, can be stored for reasonably longer period if packed at a moisture level of around 2% and ERH values of 50% in appropriate material. Mulberry fruit powder would, however, require much stringent conditions i.e. a moisture content of less than

TABLE 3. RELATIONSHIP OF HUMIDITY WITH EQUILIBRIUM MOISTURE CONTENT, TIME REQUIRED TO REACH EQUILIBRIUM, PHYSICAL CONDITIONS AND APPEARANCE OF MULBERRY POWDER* EXPOSED TO VARIOUS RELATIVE HUMIDITIES

Salt used	Relative humidity	Days required for equilibrium	Equilibrium moisture content(%) MFB**	Physical conditions
Ammonium dihydrogen phosphate	92.0	--	--	Flow reduced, got moist, mold started after 15 days
Ammonium sulphate	79.6	--	--	Flow reduced, got moist, mold started after 25 days
Sodium acetate	71.4	15	7.90	Flow reduced, colour changed
Magnesium nitrate	51.4	15	6.03	Flow reduced, colour changed
Chromium trioxide	40.0	13	5.42	Appearance good, free flowing
Potassium acetate	22.0	11	3.80	Appearance excel - lent, free flowing
Lithium chloride	11.2	13	2.02	Appearance exce- llent, free flowing

* Intial moisture content = 4.0 percent **MFB=Moisture fee basis.

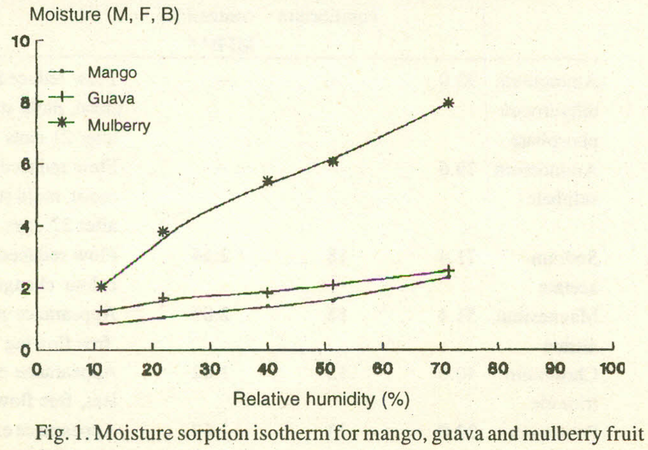

Fig. 1. Moisture sorption isotherm for mango, guava and mulberry fruit powders.

2% and ERH values of 10%, to enable the product to have maximum storage life. A controlled humidity chamber would, however, be needed for this purpose, which could be fabricated locally at a cost of a few thousand rupees.

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