December 2008 Volume 2 Issue 3

Trade Science Inc.

BioTechnology

An Indian Journal

FULL PAPER

BTAIJ, 2(3), 2008 [170-173]

Moisture sorption characteristics of soy flour at room temperature

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Received: 29th October, 2008 ; Accepted: 3rd November, 2008

ABSTRACT

The moisture content for optimum stability of full fat soy flour was studied over a relative humidity range of 10 - 90% using the static gravimetric method at room temperature (27 ± 2^{0}C). About 3g of the flour was put in a petri dish of known weight (uncovered), the dish was then placed inside a desiccator containing saturated salt solution. The flour was allowed to equilibrate over a period of 7 weeks and the EMC was calculated at the end of the period. It was found that the equilibrium moisture content for the flour ranged between 5.80 to 24.50% and that it increased with increasing relative humidity. The monolayer moisture content, determined using BET equation at Relative humidity less than 50% was found to be 6.99% (db). This suggests that a good storage stability of soy flour would be obtained when kept at conditions of relative humidity of 50% and below at room temperature and the moisture content less than 6.99%. Since this is less than the average environmental moisture content, it shows that the flour has a higher capacity for absorbing more moisture, suggesting its potential suitability for baking purposes.

KEYWORDS

Soy flour;
Moisture content;
Relative humidity;
Sorption;
Storage stability.

INTRODUCTION

Soybean's superiority to all other plant foods as a source of protein greatly influenced its use as a fortifier or supplement in many foods. Soybeans contain between 30-40 % high quality proteins[6,7] and 13.5 and 24.2% fat content[24]. Its protein quality is almost equal to that of milk, egg and meat. Soy proteins contain all the essential amino acids like other legumes however, though it has minimal amounts of the sulphur-containing amino acids, methionine[10]. The utilization of soybeans whether domestically or industrially is generally acceptable when converted to flour, the form from which other forms of products are prepared[9,19]. If this product is not well processed and stored, its shelf life could be reduced due to microbial attack, insect infestation, rancidity or moisture uptake which are closely related to its moisture content[18]. The problem of poor keeping quality of many dehydrated foods in the tropics is related to their moisture uptake during merchandising because of poor packaging materials and the moisture levels at which they were prepared[17]. Knowledge of moisture sorption of most dehydrated or formulated food is important for predicting quality stability during storage. There exists a relationship between the water content of a food and its perishability. However, various foods with the same moisture content differ significantly in perishability. Another term "water activity" (a_w)

was developed to take this factor into account and it is a better indicator of food perishability than water content. It is the equilibrium relative humidity (ERH) of a foodstuff that determines whether it will gain or loose moisture in a particular environment and that ERH is more relevant to storage behavior than moisture content[21]. Under a given vapour pressure of water, (relative humidity or water activity) in the surrounding air, a food material attains a moisture content in equilibrium with its surroundings and this is called Equilibrium moisture content[17,20]. The quantity of water absorbed or desorbed, which is a reflection of the equilibrium moisture content of food products depends on the environmental vapour pressure, the product temperature and the physical characteristics of the product[16]. The relationship between the water activity and the moisture content of a food-stuff is important in predicting quality stability during drying, storage and the selection of appropriate packaging materials for retail purposes[4]. The efficient processing and storage of soybean and its flour requires that the moisture content be reduced to appropriate levels by drying which requires the knowledge of the equilibrium moisture content and the Equilibrium relative humidity (water activity) relationship at different temperatures[2,8,27].

A plot of the EMC and the Equilibrium relative humidity or a_w of the air in equilibrium with the food at a given temperature is called moisture sorption isotherm . The relationship between a_w and EMC Equilibrium moisture content is described by the Braunner Emmet-Teller (BET) equation[5,21].

$$\frac{a_w}{(1-a_w)M_e} = \frac{1}{cM_o} + \frac{(c-1)a_w}{cM_o}$$

Where M_e = equilibrium moisture content, a_w = water activity, M_o = monolayer moisture content, c = constant

Plot of a_w/(1-a)Me against a_w gives a straight line with slope (b)= c-1/M_oc and intercept (I)= 1/M_oc where M_o = 1/I+(b) = monolayer moisture value in gH_20/ 100g dry matter.

It has generally being observed that B.E.T plots are linear plots only at water activities, $a_w < 0.5$. For water activity (a_w) > 0.5, deviation from linearity is observed with upswing of the B.E.T plot indicating that at higher water activities, less water is adsorbed than that predicted by the B.E.T equation[21]. While much data exist on the sorption properties of starchy vegetable products such as potato flakes, cassava products, there is scanty published information on sorption characteristics of soy flour. Few researchers have however, carried out studies on the moisture sorption isotherm of soybean, its flour or its products [Kuye and Sanni[12], for soy flour, Osundahunsi and Aworh[20] (Soy-tempe fortified maize based complementary food), Oluwamukomi et al.,[18] (soy-melon enriched gari), Aviara and Ajibola[4], (soybean)]. In all these studies the monolayer moisture content and the optimum condition of storage for soy flour were not determined. Therefore the objectives of this study were to determine the sorption isotherm of soy flour, its monolayer moisture content and its optimum storage condition.

MATERIALS AND METHODS

Sample preparation (Soy flour)

The soybean bought from Akure main market, was winnowed and sorted to remove broken beans, dirts, stones and other extraneous materials. Thereafter it was hydrated (ratio 1:8) in 0.2% $NaHCO_3$ for 6 hours at room temperature. It was then drained, dehulled manually by rubbing through the palms and parboiled (1:8) in water at 100^{0}C for 30 minutes[24]. It was then cooled and dried at 105^{0}C to constant weight in the hot air oven. Following drying, the beans were milled to flour using the laboratory mill. It was then packaged in sealed cellophane bag prior to use.

Sorption isotherm determination

A static gravimetric method was used for the experiment. About 3g of freshly prepared soy flour samples were placed in petri dishes and placed over salt solutions of RH (11-85%) in desiccators as described by Onayemi and Oluwamukomi[17,25]. Saturated solutions of sodium hydroxide, lithium chloride, calcium chloride, magnesium chloride, manganese chloride, sodium nitrite, sodium nitrate, potassium chloride, and barium chloride and potassium sulphate were used to maintain constant atmosphere of relative humidity in the desiccators. Excess salt was maintained in each solution. The desiccators containing salt solutions and samples of soy flour were placed inside a temperature controlled Gallenkamp DV 400 incubator, which was set at 27±2^{0}C. The temperature was monitored to within

±1.0°C. The samples were weighed daily using a Mettler PC 2000 electronic balance with an accuracy of 0.001 g. Equilibrium was considered to have been attained when three identical consecutive measurements were obtained. The dry matter content was determined by oven drying at 103°C for 72 h. The equilibrium moisture content was calculated and a plot of EMC against the %RH was made to give the sorption isotherm curve. Three replications were made for each of the determinations

RESULTS AND DISCUSSION

The results show that the equilibrium moisture content for the flour ranges from 5.80 to 24.50%. There was an increase in equilibrium moisture content with increasing relative humidity[11]. The EMC increased sharply at higher a_w. Below 50% relative humidity, small increase in the relative humidity led to corresponding little increases in moisture content this means that there will be little or no detrimental effect on the keeping quality of the flour during storage below ERH of 50% and below. The sorption isotherm curve (Figure 1) showed the typical sigmoid shape confirming type II classification which is characteristic of biological material, which sorbs relatively small amount of water at lower water activities and large amounts at high relative humidity[25].

The EMC increased up to the water activity of about 0.32 when it remained slightly constant until it shot up again after the water activity of 0.5. The gradual slope of the isotherm at water activity below 0.32 is characteristic of such products with high protein and fat content. Rockland[25] found that products with such chemical composition have been found to exhibit gradual sloping isotherm at low water activity.

The gradual slope of the isotherm of soy flour at RH below 50% is consistent with the chemical composition of the product. The steepness of the curve is not well pronounced due to the high fat content (22%) of the flour since fat is known to be hydrophobic in nature[23]. The moisture sorption characteristics of a product have been shown to be influenced by its composition, processing treatment; temperature and relative humidity[11,15]. The protein content of the flour might have played some part. Due to the hygroscopic nature of the product, at high relative humidity, the flour could suffer from mould decay and spoilage. At lower relative humidity levels, small increases in the humidity

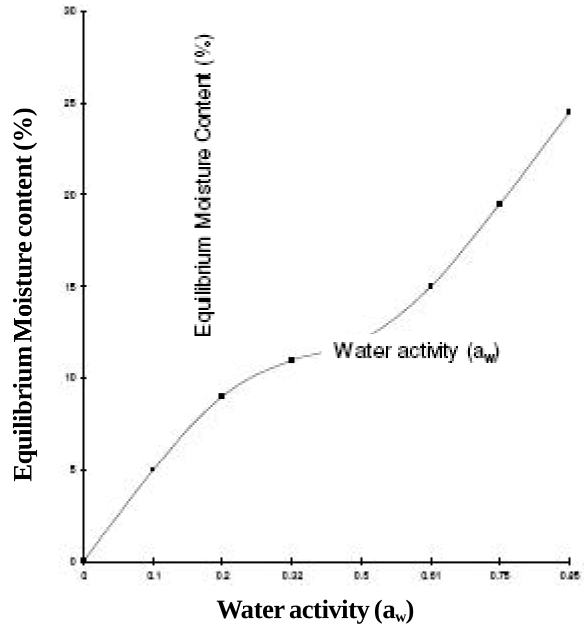

Figure 1: Sorption isotherm of soy flour at 27± 2°C

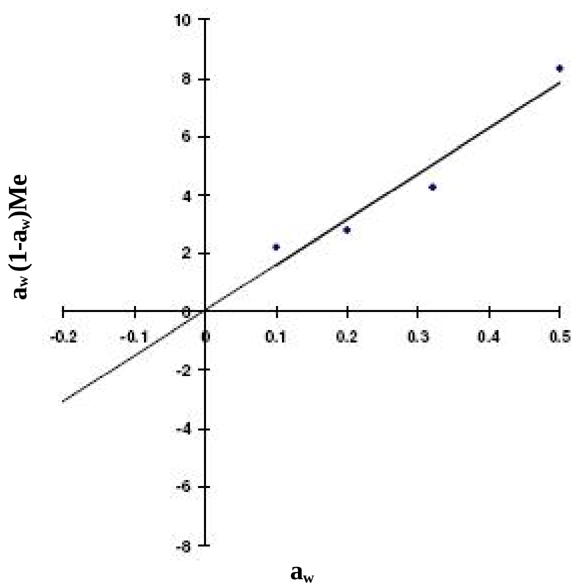

Figure 2: BET plot of soy flour at 27°C

of the storage environment will have little or no effect on the quality of the flour because mould growth is inhibited while the effects increases significantly above 50% relative humidity. This is due to the fact that the quantity of adsorbed moisture increases with an increase in a_w, indicating that more water is available for binding at the active site of the solids[14].

The Monolayer moisture content was found to be 6.41% db (Figure 2). The high coefficient of 0.941 and the linearity of the curves show that the BET model fits very well at RH less than 50%. This is consistent with the findings of Iglessias and Chirife[11]. This also agrees with the range of values of 5.5 to 7.7% for Tempe-fortified products[20], 3.2%d.b to 5.2% for the soy-melon enriched and un enriched gari[18]; 7.36%db for starchy foods on the temperature range 20-30^{0}C[11], 3.0 to 6.0%db for potatoes in the temperature range 40-70^{0}C Wang and Brennan (1991); 4.0-6.5% for some un-supplemented cassava and yam products[17]. Salwin[26] also predicted a range of 5.4-7.0%. All these were far lower than the range of storage moisture contents of 13 - 15% usually recommended as suitable for storage of some tropical foods[1,18].

This gives an indication of a long and stable shelf life of the product, provided post processing exposure is avoided. It can be inferred that adequately processed full-fat soy flour would keep well when stored at relative humidity below 50% and optimum moisture content around 6.41% (db), this would avail its use in most food application. The monolayer moisture content is of importance to the physical and chemical stability of dehydrated foods with regards to lipid oxidation, enzyme activities, non enzymic browning, flavour components preservation and structural characteristics[13]. It is the amount of water needed to form a continuous, adsorbed monolayer over the surface of a dried foodstuff.

CONCLUSION

Having established that the sorption isotherm of full fat soy flour had the typical curve characterizing most hygroscopic foods and that its moisture content increases with increasing a_w, it can be inferred that adequately processed undefatted soy flour would keep well when stored at relative humidity below 50% and optimum moisture content around 6.41% (db), this would avail its use in most food application.

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