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WATER ACTIVITY IN TEA

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The water activity (Aw) or Equilibrium Relative Humidity (ERH) of tea dhools during the drying operation was studied in relation to the moisture content. It was found that, in the range of moisture content up to 20%, the water activity changes far more rapidly than the moisture content and hence water activity is considered a more suitable parameter for further study of the behaviour of water in tea.

INTRODUCTION

Chemical and physical characteristics of most materials, particularly food materials, are considerably influenced by the amount of moisture present in them. As different constituents present in materials can have different affinities for water, characteristics too can vary not only on moisture content but also on the constituents present.

This affinity for water, or the water activity, Aw, is defined as,

$$A_W = \frac{p}{p_o}, \text{ where,}$$

p = water vapour pressure above the product surface, and

p_o = saturated water vapour pressure of pure water at the product temperature.

The equilibrium relative humidity (ERH) is defined as,

$$ERH = 100\left(\frac{p}{p_o}\right)\% = 100\, A_W\%.$$

The water activity of materials such as food stuffs are known to vary with the temperature but this variation is not normally important over the normal range of storage temperatures but may be important in drying or dehydration applications.

The water activity of a material can be considered as a property of the material itself whereas the equilibrium relative humidity can be considered a property of the atmosphere in equilibrium with the material. The equilibrium moisture content of a material, on the other hand, can be considered a property of the material in equilibrium with an atmosphere.

Water activity (or % ERH) indicates the degree of freedom of water absorbed in a material and is a better indicator of the effects of water on material characteristics than the moisture content. Exchange of water between a product and its surroundings is due to differences in water vapour pressure and not due to differences in content. Therefore the stability of the moisture content of a product is determined by any difference between the % EHR and the % RH in the surrounding.

The stability of tea during various stages of manufacture is governed, *inter alia*, by the level of moisture present in the tea. Even though the importance of equilibrium moisture content of tea has been realised for the product stability and storage of tea (Jayaratnam and Kirthisinghe, 1974 a) it is not known to have been used in the Industry. This was due to the difficulty in measuring equilibrium moisture content rapidly and accurately. This study was undertaken to determine the water activity of tea dhools during the drying operation.

MATERIALS AND METHODS

The laboratory instrument used to measure the equilibrium relative humidity in this investigation is the 'Rotronic Hygroskop DT' fitted with a sensing element DMS 100H whose measuring range is from O to 100% RH. The total accuracy at 25 °C is $\pm$0.2% RH.

This system consists of two major components, (*i*) the water activity measuring station and (*ii*) the DT indicator.

The water activity measuring station consists of a leakproof compartment where the influence of the outside humidity is negligible. A fast equilibrium time is achieved due to very low head space on the sample. The sensor used covers the entire range of 0.01 to 1.0 in water activity.

The DT indicator provides a simultaneous display of A_W and temperature in LED panel lights. There are 'trends' indicators for each parameter which show an increasing or decreasing value. The internal electronics is continuously monitoring any changes occurring in either of these parameters. When the internal monitor detects a change less than 0.0002 averaged over one minute period these trend lights will go out, thus showing that the product and sensor have reached a state of equilibrium and the display numbers are valid for a reading.

The photograph of this apparatus is shown in Fig. 1.

In order to minimise any effects due to particle size or composition of the material, samples collected were confined to 1st and 2nd dhools from orthodox—Rotorvane manufacture (these represent more tender portions of the leaf).

Various tea dhool samples were taken from the fluid bed tea drier at various stages of drying and promptly sealed for moisture in aluminium tins. This sealed tin samples were divided into two equal portions. One portion was used for equilibrium relative humidity measurement by Rotronic-Hygroskop DT maintaining the temperature between 21-24°C throughout the determinations. The other portion was simultaneously used for moisture determination by an oven method. These measurements were taken for duplicate samples and the average values for moisture content (dry basis) and % ERH were determined.

In the oven method used for determination of moisture content, 10 g samples in duplicate were dried in an oven at 98°C$\pm$2°C (at 1400 m above mean sea level) for 4 h. The loss of moisture was measured and the moisture content was expressed on a dry basis.

RESULTS AND DISCUSSION

Desorption isotherm relating moisture content (dry basis) and water activity (ERH) is given in Fig. 2 and the results are expressed by the equation given by Henderson (1952):

$$1 - \varnothing = e^{-KTM^n}$$

where $\varnothing$ = water activity,

T = absolute temperature, °K,

M = moisture content (dry basis), percentage,

and, K, n = constant characteristics for given materials.

This equation can be re-written as,

$$\log_e(-\log_e(1-\varnothing)) = \log_e T + n \log_e M - \log_e K$$

The plot of $\log_e(-\log_e(1-\varnothing))$ against $\log_e M$ at constant temperature should therefore produce a straight line.

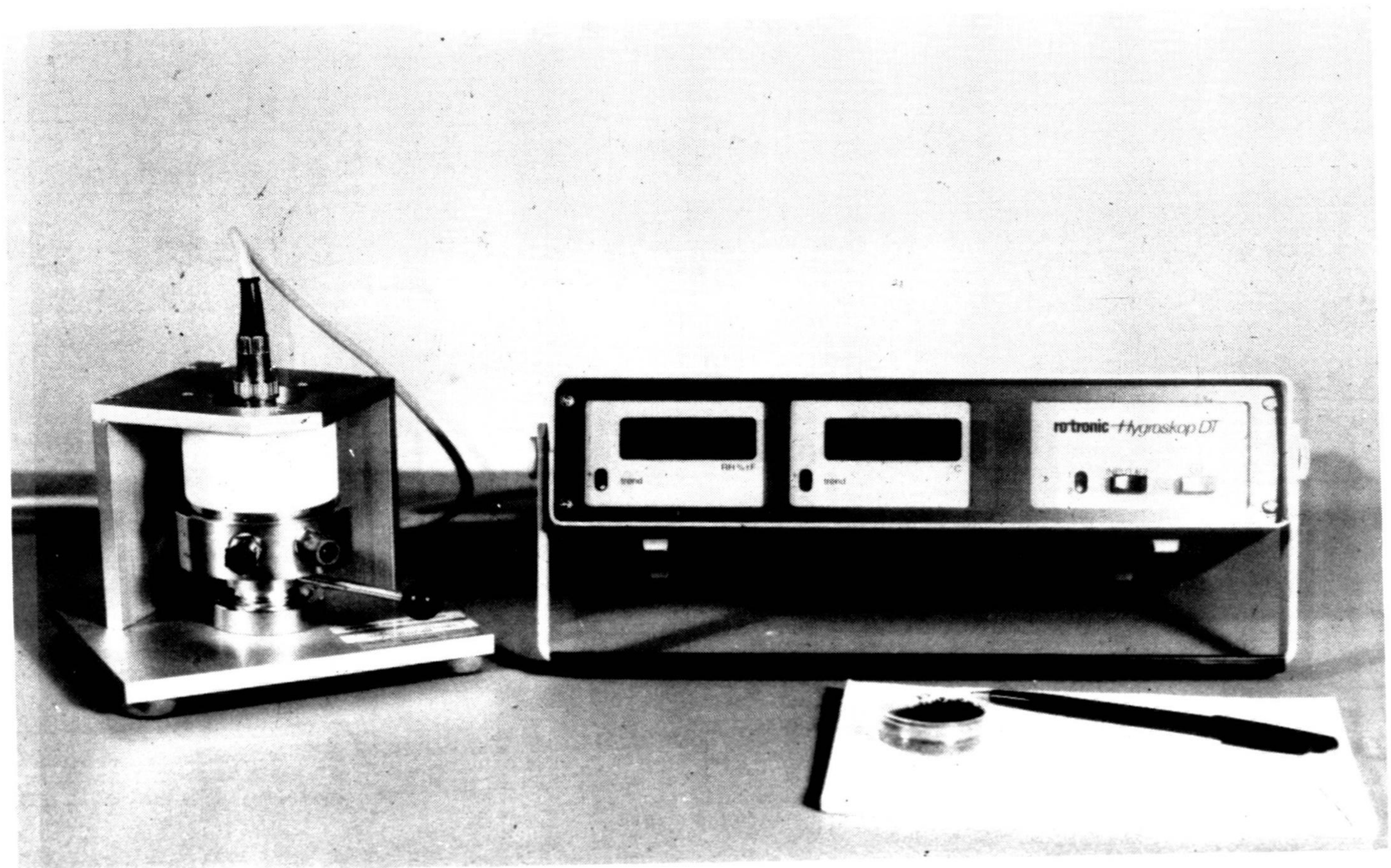

Fig. 1 — The Hygroskop DT and water activity measuring station.

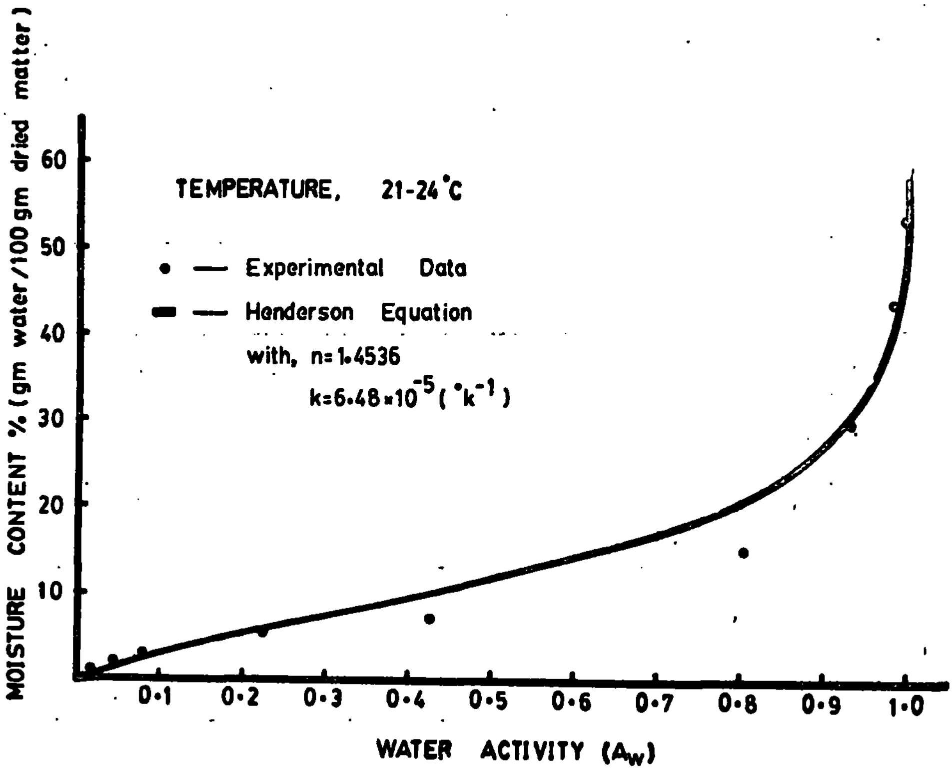

Fig. 2 — Desorption isotherm relating moisture content and water activity.

The experimental data on desorpting tea dhools could be fitted on this equatiou with a correlation coefficient of r=0.99 (significant at P= 0.001). The constants were found to be, $K=6.48X10^{-5}$ ($°K^{-1}$) and n=1.4536. A feature of the above isotherm is the very rapid decrease in water activity with the moisture content. For example, the water activity decreases from 0.8 to 0.1 when the moisture content is decreased from 21% to 3.0%. It is important to note that most enzymic reactions are slowed down at a water activity level below 0.8.

The results reported here are significantly different to those reported by Jayaratnam and Kirthisinghe (1974 b). It is probable that this difference is due to the fact that the present study refers to desorpting tea dhools, i.e. sampled during the drying process, whereas the earlier study refers to characteristics of absorbed moisture from graded teas. Desorption characteristics of absorbed moisture from graded teas were again studied using the water activity meter and the constants were found to be not significantly different from results obtained in the earlier study (Table 1).

TABLE 1—*Characteristic constants for desorpting moisture from graded teas*

Sample	*n*	*K*
BOP (at 21°C) Using equilibrium moisture content method, Jayaratnam and Kirthisinghe (1974a)	2.32	$1.10x10^{-5}$
Water activity method (at 22.5° C)		
BOP	2.04	$2.89x10^{-5}$
BOPF	2.09	$2.39x10^{-5}$

The following conclusions could be arrived at from the present study.

(*i*) Water activity measurement is a relatively quick method of studying desorption characteristics and the reliability of the method is the same as the classical method of measuring equilibrium moisture contents.

(*ii*) The desorption phenomena of tea dhools can be satisfactorily explained by the Henderson equation.

(*iii*) The characteristic constants for desorpting tea dhools are significantly different to those of desorpting absorbed moisture from graded teas. The former is more representative of the drying process while the latter is more representative of any secondary drying operations.

(*iv*) When the temperature of fermenting tea dhools is not a constraint, the fermentation reactions will continue to a moisture level of about 20% before retarding due to insufficient water activity.

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