EQUILIBRIUM MOISTURE CONTENT OF CACAO BEANS

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The moisture content of cacao beans depends on the relative humidity and temperature of the surrounding atmosphere. The change of moisture content in storage and drying depends on the product moisture content and the conditions of the surrounding atmosphere. Further theoretical developments in drying will be based on use of equilibrium data. The moisture content which a product attains in a given relative humidity and temperature environment is known as the equilibrium moisture content for that environment. The vapor pressure of a bean is the same as the vapor pressure of the air surrounding it at equilibrium conditions.

PREVIOUS WORK

Extensive data on the equilibrium moisture content of cacao beans have not been reported. Limited information gives a moisture content of 7.3 percent at 75 percent humidy and 8.7 percent at 85 percent humidity, but the temperature is not given (2). The procedures for determining the equilibrium moisture contents of hygroscopic maerials is explained in detail in Drying Farm Crops (1) Also, the equilibrium moisture content values of many products are included.

PROCEDURE

Hybrid cacao beans from the Granja Agrícola Experimental, Palmira, were used for the tests. The beans were fermented 24 hr until the surface mucilage layer was removed. Two wet beans were weighed and suspended in a jar in which a particular relative humidity was maintained. The relative humidity was maintained with a sulfuric acid

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All moisture content data are expressed on a wet weight basis.

solution. The amount of sulfuric acid was changed to give the desirable relative humidity.

As the amount of sulfuric acid is increased in the acid-water solution in the closed container, the lower the relative humidity maintained above the solution. Three different humidities were used: 16, 56, and 87 percent. The containers were then placed in boxes in which three different temperatures. were maintained: 5, 25, and 45 deg Centigrade. Thus, nine complete sets of data, with duplicate results were obtained. The samples were weighed periodically until a constant weight was reached. The moisture content of the beans was then determined, known as the equilibrium moisture content. The moisture content of the beans was determined by holding for 3 days in an air oven at 212 deg F.

RESULTS

The moisture content attained by the beans after 24 days is given in Figure 1. The cacao beans were originally at 43.5 percent moisture content. All beans lost moisture to attain equilibrium conditions in the atmosphere in which they were placed. Therefore, the data may be designated as desorption equilibrium moisture content curves. Ninety five percent of the change from the original we weight to the final equilibrium condition took place in the first six days. The beans in the 25 deg C and 87 percent relative humidity atmosphere were completely covered with white mold five days after the beginning of the tests. The beans at 87 percent at the lower and higher temperature of 5 deg C and 45 deg C. did not mold in the 24 day period. The beans at 16 and 56 percent relative humidity did not mold in the 24 day period.

DISCUSSION OF RESULTS

The moisture content of a cacao bean increases as the temperature is decreased (with the relative humidity constant), and as the relative humidity is increased (with the temperature constant). For proper storage and processing it is generally desirable to dry the cacao beans to 8 percent moisture content (3).

It would be impossible to dry beans to 8 percent moisture content if the air at 25 deg C. has a relative humidity above 70 percent. Thus, the beans must be heated to remove the moisture. If the air is heated to 45 deg Centigrade and is at 50 percent relative humidity, the beans could be dried to 4.5 percent moisture content. Although it is not desired to dry to this low moisture content, the drying rate is faster with the heated air nearly in proportion to the ratio of moisture contents.

The exact relative humidity at which mold growth begins at the 25 deg C. level was not determined, although the mold growth was very obvious at only the 87 percent relative humidity level. It is generally considered that mold growth is considerable above 75 percent relative humidity. In the Palmira area where the tempera-

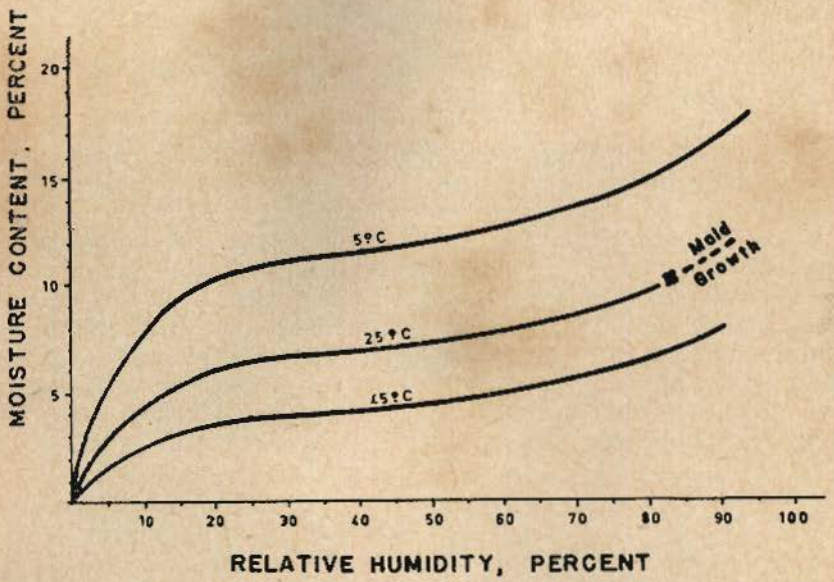

FIG 1.— Equilibrium moisture content of Cacao beans.

ture is near 25 deg C it can be noted that a moisture content as desidered for proper storage of 8 percent is slightly below the danger point for mold growth. The cacao bean would have to be dried to 8 percent moisture content in less than 5 days in an atmosphere of 87 percent relative humidity.

In a location where the storage temperatures would approach 30 deg C it woul be necessary to reduce the moisture content to 7.5 percent to avoid mold growth.

The data can be used to determine the change of moisture content in storage. If beans are dried to 7.5 percent moisture content and placed in a storage at 20 deg C and 40 percent relative humidity, the beans will gain moisture to 8.0 percent.

Effects of various combinations of moisture content humidity and temperature effects can be determined from Fig. 1. Slight heating of the air might be required in some cases to maintain desired environment.

Exactly the same values could not be expected for all varieties of cacao beans. However, the similarity of these data and those previously reported (probably for normal atmospheric temperatures near 25 deg C) indicates little variation in different varieties. The equilibrium values are considerably less, from 3 to 5 percent, than those for cereal seeds(1).

SUMMARY

The equilibrium moisture content for cacao beans was determined by desorption techniques.

Wet beans at 43.5 percent moisture content were placed in constant relative humidity atmospheres of 16, 56 and 87 percent, maintained by sulfuric acid solutions. Temperatures of 5, 25 and 45 deg C were maintained for the three different relative humidities. To maintain cacao beans at not more than 8 percent moisture content, the relative humidity must not exceed 70 percent at 25 deg C., and 60 percent at 20 deg C. A graph is included to make these comparisons for other temperatures and humidities. The data are useful for determining the extent of change of moisture content during storage and drying. The equilibrium moisture contents are 3 to 5 percent below the values for cereal grains.

RESUMEN

Por medio de técnicas de desorpción se determinó el contenido de humedad de equilibrio en granos de cacao.

Estos granos, con un contenido de 43,5 por ciento de humedad fueron colocados en atmósferas de humedad relativa constante de 16, 56 y 87 por ciento mantenidas por medio de soluciones de ácido sulfúrico; las humedades mencionadas correspondieron a temperaturas de 5, 25 y 45 grados C. respectivamente. Con el fin de mantener los granos de cacao a un contenido de humedad no mayor del 8 por ciento, la humedad relativa no debe exceder del 70 por ciento a 25 grados C., y 60 por ciento a 20 grados C.

Se incluye un gráfico que expresa estas comparaciones para otras temperaturas y humedades. Los datos se consideran útiles para determinar el cambio de humedad durante el almacenaje y secado de los granos de cacao. Los contenidos de humedad de equilibrio son de 3 a 5 por ciento más bajos que aquellos indicados para granos de cereales.

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