A knowledge of the effects of high temperatures on the drying of alfalfa is required in order to achieve rapid and efficient forced drying. A considerable amount of investigation has been reported in regard to drying alfalfa at temperatures up to 200°F, usually under field conditions. In this study, alfalfa leaves were exposed to heated air at temperatures up to 1400°F for given periods of time in order to determine the rate of drying under various conditions of time and temperature. This information will be useful in designing a compact, efficient unit for drying alfalfa leaves. Ultimately, this unit may be made mobile.

Field stripping alfalfa leaves from the stems and drying them with heated air was reported by Whitney and Hall (4). It was indicated that harvesting only the leaves of alfalfa is feasible.

The objectives of this study were to determine the effects of the following variables on the drying of alfalfa leaves: (a) temperature, (b) exposure time, (c) weight of leaves, and (d) the interactions of the three preceding factors.

Alfalfa in the early bloom stage of maturity was field cut and brought into the laboratory. Each test sample consisted of five sets of trifoliates. Since weight of leaves was one of the variables being investigated, no attempt was made to pick leaves identical in size; however, in order to minimize error, very small leaves were not used. Three replications of each time-temperature combination were made.

Heated air was provided by an apparatus consisting of an oxy-acetylene welding torch inserted into an insulated 3-inch, extra strong steel pipe as shown in figure 1. Metal screening was fitted inside the mouth of the pipe to protect the samples from the flames. This apparatus provided ample heat, abundant air circulation, and good temperature control. The temperature of the drying air was checked constantly by means of a thermocouple located in the area in which the samples were held for drying. A stop watch was used to determine the duration of drying time.

Each group of five trifoliates, shown in figure 2, was weighed to the nearest tenth of a milligram before being exposed to the heat. A cluster of five trifoliates was impaled with a thin wire as shown in figure 3. This was accomplished by piercing one leaflet of each trifoliate with the wire. The wire was used to suspend and rotate the leaves in the hot air stream.

After the heat treatment, a cooling period of about 2 minutes at room temperature was allowed and then the leaves were reweighed. The amount of moisture lost through heating was thereby determined. A well-programmed succession of weighing, heating, and reweighing was important in order to minimize and standardize loss of moisture through air-drying.

A careful visual check was made of the dried leaves to assure that they were not charred. Limits for the maximum exposure time at any given temperature were established by noting the tendency of the leaves to char. In determining exposure limits it was noted that charring usually commenced on the periphery of the leaf and progressed inward. The samples were subjected to temperatures from 200°F to 1400°F varied in 200°F increments and for predetermined intervals of time from 0.02 minutes to 3.00 minutes, depending on the temperature.

A linear regression analysis of the data was made to determine the effect of time on moisture loss at selected temperatures. The data were then analyzed by means of a stepwise multiple regression analysis using a digital computer to determine the effect of time, temperature, weight of the leaves, and the interaction of the preceding three variables on the moisture loss.

The general model for the multiple regression equation was:

\[ Y = a_0 + a_1X_1 + a_2X_2 + a_3X_3 + a_4X_1^2 + a_5X_2^2 + a_6X_3^2 + a_7X_1X_2 + a_8X_1X_3 + a_9X_2X_3 + \ldots + 1 \]
only those equations which were significant and had an R² value at least one percent higher than the preceding equation were considered. This rule has been adopted by some statisticians. The addition of variables beyond the above-stated amount generally results in an overall increase of variance which more than offsets the increase in R². Examination of the final R² in Table I shows that it is relatively high and that it was obtained in four steps.

Linear regression equations were also developed. Equations showing moisture ratio vs. time at each temperature level were derived. The equations and their respective r² (2) values are shown in Table II.

From the practical point of view the important controllable variables in predicting a given drying rate are time and temperature. Certainly, it would be both difficult and impractical to control leaf size. Hence, a plot of the equations, as shown in Figure 4, gives one an opportunity to predict at a glance the general drying rate of alfalfa leaves for any given temperature, the temperature must be lowered, perhaps to 400°F, for final drying; otherwise the leaves will burn or char before a safe moisture level for storage could be achieved. The exposure time safe for ultra-high temperature drying is in the order of 0.02 to 0.03 minute.

Leaf weight seems to be a very important variable in predicting the drying rate of alfalfa leaves. Temperature appears to be the second important factor. Hence, to predict accurately the amount of moisture that will be removed from a leaf at a given temperature and time interval one must know the oven-dry weight of the leaf.

The amount of moisture lost by alfalfa leaves subjected to temperatures between 200°F and 1400°F can be predicted with considerable accuracy through the use of multiple regression equations that consider the effects of time, temperature, weight of leaves, and the cross-products of the three preceding variables. However, for most engineering work the graphs showing time vs. drying relationships at a given temperature would be sufficient for an estimate of the drying rate of alfalfa leaves.

If drying purposes alfalfa leaves can be exposed to air temperatures as high as 1400°F for limited periods of time. Although very rapid partial drying was achieved at the highest temperature, the temperature must be lowered, perhaps to 400°F, for final drying; otherwise the leaves will burn or char before a safe moisture level for storage could be achieved. The exposure time safe for ultra-high temperature drying is in the order of 0.02 to 0.03 minute.

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