Alfalfa Drying Properties and Technologies – in Review

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Abstract: Fresh alfalfa must be dried to moisture contents of 8~10% for storage and processing. However, the physical and compositional characteristics of each component differ greatly. The drying properties of alfalfa were studied, which obtained some meaningful results. Dimensional analysis method was used to design rotary dryer and determine the drying parameters. [Nature and Science. 2004;2(4): 65-67].

Key Words: alfalfa; dry; property

1. Introduction

Alfalfa (*Medicago satica*, L) that is often called "Queen of forages" is the most important forage crop species in the world. In addition to being an excellent source of protein, vitamins and minerals, alfalfa is important for improving the soil. Good quality alfalfa hay contains digestible fibers and a useful range of minerals and vitamins. Since 1970 onwards, the processing of alfalfa to produce products like pellets and cubes is increasing due to ease of transportation and handling of these products.(Rotz C.A, 1984)

Fresh alfalfa must be dried to moisture contents of 8~10% for processing. The most popular form of artificial drying is in a chopped form in rotary dryers. The crop is mowed, conditioned by crushing or crimping of the stems, and the plant material is laid in the swath for drying. The partially dried forage is picked up and cut into small pieces. Fresh alfalfa may also be cut into pieces immediately after harvest. Alternatively, alfalfa is harvested and allowed to cure in the field (sun-cure) to balable moisture content of about 20 to 40%. These bales are then brought to the plant, chopped into 50 mm lengths and dried further to less than 10% for further processing. Bales are also produced with hay having 40% moisture and these bales are dried in a barn dryer to safe storage moisture of less than 15%. The dales may be fed to animal's long hay or processed in the form of cubes and dense bales for export market.(Hanson A, 1988)

2. Alfalfa drying properties

Unlike grain, alfalfa chop is not a homogenous material. It contains leaves, coarse stems, stems with leaves attached and fine stems. The physical and compositional characteristics of each component differ greatly. The leaves are thin and elliptical in shape, having large surface area for drying as well as the natural openings of the stomata, which aid moisture release. The leaves contain 30% protein compared to only 10% in the coarse stems. The coarse stems have hollow cross section with the external cuticle serving as a natural barrier. The fine stems, which comprise 10% of chop mass, are more succulent and approximate solid cylinders. (Patil RT, 1992)

Due to differences in their physical and chemical characteristics, each component must be studied separately for their dehydration characteristics to get a clear understanding of the drying operation of alfalfa and to better monitor the quality of the end product affected by the drying process. At present, the following research results were obtained.

It was demonstrated that at 60℃, alfalfa leaves were faster 2.5 times than stems to reach to the same moisture level of 8%. It may be therefore advisable to dry leaves and stems separately and later on try-mixing them in the proportion desired for further processing. Shorter the stem length is, and faster the drying rate of alfalfa is. The drying constant k was found to decrease logarithmically with the length of stem. It is therefore recommended that lowest possible stem length is used to achieve uniform drying whenever possible. The thin layer drying characteristics of alfalfa indicates that the fine stems dry even at faster rate than the leaves. (Patil RT, 1992)

At lower air temperature of 40℃ drying takes place initially at a constant rate and at 60℃ in the falling rate. The falling rate at 40 and 60℃ can be divided further into two or three periods. However, above 100℃ the drying temperature rate initially were found to increase with moisture content. This phenomenon may be due to thermal damage to waxy surface, which helps in increasing the drying rate up to a critical level. After this, the rate of water replenishment to the surface was not as fast as evaporation and hence the drying takes place in the falling rate period. The drying rates were initially higher and reduced as the gradient of initial and final moisture lowered. The drying rates g/g-min at each 0.01 reduction in moisture was higher at higher temperatures. This indicates that unlike other food grains the casehardening effect was not experienced in alfalfa at high temperature drying. In fact, the thermo-mechanical damage to the cuticular layer helps in increasing the drying rate and it was therefore possible to use higher temperatures.(Patil RT, 1994)

The drying behavior of alfalfa showed the rate of moisture migration increased with increased drying air temperature, and like food grain the case hardening effect was not experienced. This could be attributed to its fibrous and exposed microstructure to dying environment and thermo-mechanical damage to the outer surface. Considerable changes in the physical attributes were found during drying which need to be considered during designing the dryer for alfalfa. Alfalfa can be dried up to 175℃ without appreciable damage to its physical structure.

At air temperatures above 300℃, the extremely rapid drying of chop in thin layer allowed the chop to burn after a certain exposure period which puts limits on the allowable exposure time of alfalfa at those temperature up to 1000℃ are used. Though the large throughput in rotary dryers produces the cooling effect due to evaporation of moisture, it is possible that some material may get exposed to excessively higher temperature for longer times.(Patil RT, 1994)

The typical drying curves for alfalfa chop and also goodness of fit at various drying air temperatures at the difficult initial moisture content. The non-linear relationship between moisture ratio with drying time was up to 200℃ for chop at initial moisture content of 3.10. Chops at initial moisture of also showed a nonlinear relationship up to 200℃. At moisture contents of 0.69 and 0.26, the nonlinear relationship was up to 200℃and 150℃ drying air temperatures, respectively. For the rest of the conditions, the relationship was linear.(Mujumdar AS, 2000)

The alfalfa protein is highly tolerant to heat. Research results show that protein solubility did not decrease up to 150℃ for leaves and 100℃ for stems. Damage to protein is significant at 150℃ for stems at 200℃ for leaves.(Patil RT, 1993)

Crushing chopped alfalfa at lower initial moisture contents (20% and 40%) expedited the drying rates. Crushing three times between longitudinally grooved rollers improved the drying rates However, increasing-crushing frequency beyond three times did not improve drying rates. The use of potassium carbonate as a chemical treatment on fresh alfalfa was effective in reducing the drying time by about 50% over the control, but chemical treatment did not the drying times of pre-wilted alfalfa due to the increased moisture content of the treated sample. Treatments with either steam or urea or a combined mechanical-chemical treatment did not reduce drying times because these treatments increase the initial moisture content of the forage samples.(Sokhansank S, 1996)

3. Alfalfa drying technologies

Rotary dryers are normally employed in the chemical and pharmaceutical industry but also are used to dry agricultural products like alfalfa. A rotary dryer basically consists of a cylindrical shell that rotates around its longitudinal axis. The inside of the shell is equipped with lifting flights. The material to be dried is introduced in a continuous way through one end of the dryer. The hot air is also introduced in the dryer where it contacts the products to be dried. Material is lifted by the flights during the rotating movement and dislodged falling back as it cascades through the hot air stream. The air provides the necessary heat to drive off the water in the product by vaporization. The product that passes through a rotary dryer has a more intimate contact with the air than in other types of dryers and so the drying is achieved in a more uniform way. As an essential dryer, the rotary dryer is widely used in the alfalfa drying process. Therefore, it is an important procedure to design a perfect rotary dryer for alfalfa drying, whose performance characters are the low energy consumption and the high alfalfa quality. However, some rotary dryers were designed base on the other material such as the chemical material, to determine the structure and process parameters, which is unfit for the alfalfa drying.(wood HC, 1990)

Rotary drying is a complex process that involves not only thermal drying but also transport of the product. Rotary dryers constitute a highly non-linear system that is dependent both on time and position and whose modeling is very difficult. It is not easy to obtain the proper results to describe the alfalfa drying process in convention experiment design method such as quadratic rotary regress design method. Dimensional analysis method was used to determine the variables which reduce significantly the amount of experimental data that must be collected. It is based on the premise that physical quantities have dimensions and that changing the units measuring dimensions does not alter physical laws. Thus, the phenomenon under investigation can be described by a dimensionally correct equation among the variables. A dimensional analysis provides qualitative information about the model relevant to rotary drying process. It is especially important when it is necessary to conduct experiments in the modeling process because the method is helpful in testing the validity of including or neglecting a particular factor, in reducing the number of experiments to be conducted to make predictions, and in improving the usefulness of the results by providing alternatives for the parameters employed to present them. Dimensional analysis has proven useful in physics and engineering for many years and now even plays a role in study of the life sciences, economics, and operations research. Dimensional analysis method was used in the modeling process in a rotary alfalfa dryer to increase the efficiency of an experimental design.

The Jiang-theorem and G. Murphy-Jiang theorem in dimensional analysis are characteristic of less experiment number of times and easy operation and reasonable results.

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