Table 4 .... Effect of Heating Chopped Alfalfa[a] on Carotene Loss during Subsequent Storage of Meal

Hours in oven at 212 F	*Initial carotene p.p.m.*	*Carotene retained 1 week—149 F percent*
½	229	37
1	228	37
2	197	37
3	176	28
4	149	21
5½	112	18
7½	86	15

[a] Fresh-frozen alfalfa from Ryer Island, California.

protein nutritive value with air having temperatures as high as 240 F provided that the air flow rate is approximately 110 cfm per bushel so that the average moisture of the batch is reduced to safe storage level in about 1½ hr or with air having temperatures up to 180 F with air flow rates of 50 cfm per bushel so that drying is accomplished in about 3 hr.

The market grade of corn may be affected more rapidly by growth of microorganisms than by any other factor, except insect and rodent damage. Microorganisms will not grow in grain at safe storage moisture content.

Grain uniformly dried to safe moisture levels (see Table 1) is less subject to insect damage during storage than grain containing pockets of high moisture. Rodent damage can be eliminated by good housekeeping and the use of effective poisons.

The rate of growth of microorganisms such as molds and bacteria is a function of grain moisture, temperature, and available food or physical damage of the seed coat. Growth can be thought of as an oxidation process resulting in the production of carbon dioxide. Since the evolution of carbon dioxide can be readily measured, it can be used as an index of deterioration. Saul reports that field-shelled corn will be safely dried if no more than 8 grams of carbon dioxide is produced per kilogram of dry matter.[23]

Table 5.....Effect of underdrying and overdrying on carotene stability in a commercial dehydrator

Inlet temperature, F	*Dehydrator control gage*	*Moisture %*	*Initial carotene[a] ppm*	*Carotene retained 1 week—149 F, %*
800	Normal	10.9	308	29
1,200		9.8	260	28
1,400		7.6	282	27
1,530		7.0	255	29
1,540		7.6	211	31
1,500		6.3	301	26
1,200	Slightly wet	10.9	260	31
	Normal	10.2	237	29
	Normal	9.0	188	29
	Normal	8.3	181	37
	Slightly scorched	7.9	212	32
1,400	Slightly wet	10.9	190	24
	Slightly wet	11.9	127	29
	Normal	5.9	292	33
	Normal	8.8	302	29
	Normal	9.0	159	29
	Slightly scorched	8.7	172	28
	Scorched	5.7	197	38
1,500	Wet	21.3	194	28
1,600	Normal	6.1	256	30
1,600	Slightly scorched	4.7	193	37

[a] Corrected for moisture.

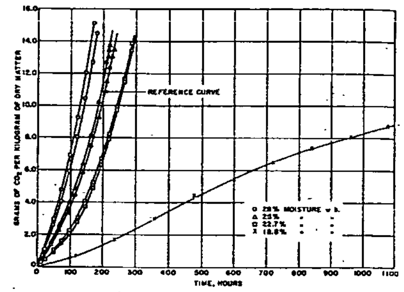

Fig. 11 .... CO_2 Production of Field-Shelled Corn

Fig. 11 shows curves of data obtained by Steele and Saul on the production of carbon dioxide at 65 F in field-shelled corn at moistures ranging from 28 to 18.8 percent.[24] They obtained similar data for temperatures ranging from 35 to 90 F. The data curves for all temperatures and moistures measured were referred by the use of multipliers to the reference curve shown in Fig. 11. Fig. 12 is a plot of the temperature multipliers or relative deterioration rate due to temperature. Fig. 13 is a plot of the relative deterioration rate due to moisture. These are related in the following manner:

$$\tau_M = \frac{\tau_R}{(R_T)(R_M)} \tag{11}$$

where

τ_M = time required to produce CO_2 at specific moisture content and temperature, hours.
τ_R = time required to produce a given quantity of CO_2 as read from Fig. 11, hours.
M = percentage moisture content, wet basis.
T = Temperature Fahrenheit.
R_T = relative deterioration rate due to temperature.
R_M = relative deterioration rate due to moisture.

Example 1: Predict the time required for 28 percent moisture corn at 55 F to produce 8.0 gms per kilogram of dry matter.

Solution: The time required for the reference sample to produce 8.0 gms CO_2 is 158 hr, from Fig. 11. The relative grain deterioration rates are 0.52 for 55 F and 1.42 for 28 percent moisture. The predicted time for 28 percent moisture corn at 55 F to produce 8.0 gms CO_2 is equal to the time for the reference to produce 8.0 CO_2 divided by the product of the relative rates, or:

$$\tau_{28\%,55F} = \frac{\tau_R}{(R_T)(R_M)} = \frac{158}{(1.42)(0.52)} = 214 \text{ hr}$$

This allows prediction of the time available for safely drying field-shelled corn. Twenty-eight percent should be dried within 214 hr if the average wet-bulb temperature of the drying air is 55 F.

Cotton Drying

The desirable lint moisture content for best results in ginning cotton appears to be 5–7 percent with an optimum moisture content of 6 percent.[25] Since cotton is very hygroscopic, it should be dried just prior to ginning. The wide variation in incoming moisture content usually requires different amounts of drying for each load. Rapid changes in the amount of drying required can best be handled by the use of a multipath drying tower in which the cotton is exposed for various lengths of time (2–10 sec) at temperatures not to exceed 350 F. The air-to-cotton ratio may range from 40–100 cfm of air per pound of cotton.[25]

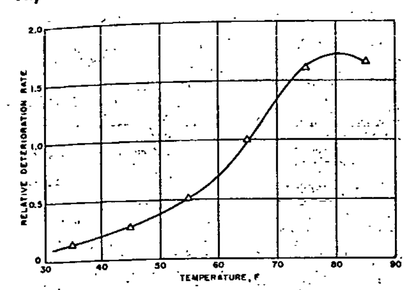

Fig. 12 .... Relative Grain Deterioration Rates with Temperature

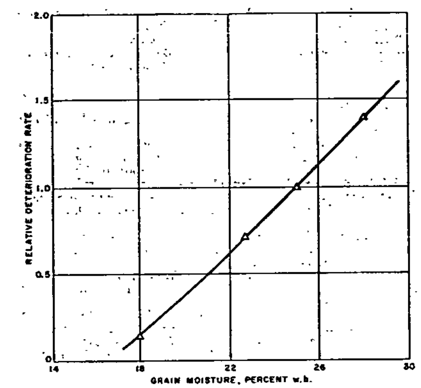

Fig. 13 .... Relative Grain Deterioration Rates with Moisture Content

The germination of cottonseed is unimpaired by drying provided the internal cottonseed temperature does not exceed 140 F.[26] This temperature is not exceeded in the tower drier described above. However, the moisture content of the seed may be above the recommended level of 12 percent following the multipath tower drying. Drying seed in a triple-pass drum at 250–300 F with an exposure time of 4 min, followed by cooling, has been effective in reducing moisture content, inhibiting the formation of free fatty acids, and improving germination over undried seed.

Peanut Drying

Peanuts will normally have a moisture content of about 50 percent at time of digging. By allowing the peanuts to dry on the vines in the windrow for a few days, much of this water will be removed. However, peanuts will normally contain 20–30 percent moisture when removed from the vines and some artificial drying is necessary. Drying should begin 6 hours after harvesting to keep the peanuts from self-heating. Both the maximum temperature and the rate of drying must be carefully controlled to maintain quality. High temperatures result in off-flavor or bitterness. Too rapid drying without high temperatures results in blandness or the lack of capacity of the nuts to develop flavor on roasting.[27] High temperatures, rapid drying or excessive drying will also cause the skin to slip easily and the kernels to become brittle. These conditions result in high damage rates in the shelling operation and can be avoided if the moisture removal rate does not exceed ½ percent per hour. Because of these limitations, continuous flow drying is not usually recommended for peanuts.

Rice Drying

Of all grains, rice is probably the most difficult to process without loss of quality. Rice containing more than about 12 percent moisture cannot be safely stored for long periods, yet the recommended harvest moisture content for best milling and germination ranges from 20–26 percent.[28] When harvested at this moisture content, drying must be begun promptly to prevent the rice from souring.

Since the market for rice is for polished whole kernels of rice, it is necessary to prevent damage in the form of stress cracks produced by rapid moisture removal. Head yield is the percentage of rough rice which can be milled as unbroken kernels. Schmidt and Hukill report that best milling results were obtained with drying air with saturation deficits between 1.0 and 2.0 inches of mercury.[29] Saturation deficit is the difference between the saturated water vapor pressure at the dew point and at the dry-bulb temperature of the air.

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