

Safe Grain Storage Period

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Safe grain storage periods represent the maximum allowable number of days to store grain without major deterioration. Grain deterioration results in decreases in its value and quality. Deterioration is usually caused by biological activity in the grain mass. Unfortunately, grain begins deteriorating at harvest or maybe even before harvest. Biological activities include fungi, bacteria, insects, rodents and sprouting of grain. Another important item that might lead to grain deterioration is continued grain respiration. Researchers explain that respiration occurs when glucose (from the grain) reacts with oxygen (from the air) and produces carbon dioxide, water vapor and heat. The production of water vapor and generation of heat explains why we sometimes find moist and hot spots in the grain bulk.

Grain deterioration is usually expressed as percent of dry matter loss. The value of 0.5% dry matter loss level (loss of one U.S. grade level) is accepted as the criterion for allowable storage time. Therefore, the goal of this fact sheet is to provide grain producers with a simple tool to estimate the actual safe storage period of grain under various conditions. Understanding the safe grain storage period will help in making decisions to maintain the quality of grain.

Safe Storage Period Tables and Charts

Several challenges make it difficult to maintain the grain moisture content and temperature at the same

level from the day of harvest to the day of marketing. One of these challenges is the change in grain temperature due to the generated heat from the grain during the storage period. In addition, weather may vary significantly during the storage period. As a result, grain may deteriorate and drop in market grade if the safe storage period is inaccurately calculated.

The following should be considered to determine safe storage period of grain:

1. The allowable storage time begins at harvest.
2. Grain has only one life and all time after harvest is part of this life.
3. The temperature in the safe storage period tables and charts represents grain temperature and not air temperature.
4. The grain moisture content is measured by subjecting grain to 212°F for 72 hours in an oven.
5. The chart or table values assume clean grain.
6. At the end of the safe storage period, grain may deteriorate the maximum amount possible without dropping in market grade.
7. There is a variability associated with grain safe storage periods due to the variability of grain.

The following tables (Table 1 through 3) as well as Figure 1 show the safe storage periods for corn, soybeans, rice and wheat. The safe storage period for grain depends on grain moisture content and grain temperature during the storage

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period. For example, Table 1 shows that if corn is stored at 60°F and 17% moisture content, the maximum safe storage period is 88 days. Decreasing the corn temperature to 55°F increases the safe storage period to 133 days. On the other hand, if the corn temperature stayed the same (60°F) and the moisture content decreased to 15%, the safe storage period would increase to 275 days.

Figure 1 also shows the safe storage period for corn. Assume that corn was stored at 45°F and 19% moisture content. On the vertical axis, locate the grain temperature of 45°F. Draw a horizontal line going right until it intersects with the 19% moisture content curve (it is not shown on the graph, but you can estimate the location between the 18% and 20% moisture curves). From the intersection point between the horizontal line and the curve, draw a vertical line down until it intersects with the horizontal axis. It will show the safe storage period for corn under the conditions of 45°F and 19% moisture

content. Under these conditions, corn can be safely stored for about 150 days. It should be mentioned that the results from the table and the figure may not be exactly accurate due to the variability of the corn.

Increasing the grain temperature and/or increasing its moisture content decreases the safe storage period. In other words, the higher the temperature and/or the higher the moisture content, the higher the risk of the grain going out of condition and the shorter the time the grain should be stored. Once again, it is safe to store soybeans, for example (see Table 3), up to 278 days if the soybean temperature and moisture during the storage period remain at 60°F and 13%, respectively. However, as mentioned earlier, it is not practical to assume that the grain temperature and moisture content will remain constant during the storage period. Therefore, these tables should be used to *calculate the accumulated percentage of the safe storage period* (see the next step).

Table 1. Safe Storage Period for Corn (Days).

Corn Temperature (°F)	Corn Moisture Content (% Wet Basis)						
	15	17	19	21	23	25	30
75	115*	37	16	9	6	5	3
70	154	49	22	12	8	6	4
65	206	66	29	16	11	8	5
60	275	88	39	22	14	10	6
55	414	133	58	32	21	14	8
50	621	199	88	48	30	21	12
45	931	299	131	72	45	32	18
40	1413	448	197	107	68	48	27
35	2126	671	295	161	102	72	41

*It should be mentioned that these values assumed about 0.5% dry matter loss.

Table 2. Safe Storage Period for Soybeans (Days).

Soybean Temperature (°F)	Soybean Moisture Content (% Wet Basis)									
	10	11	12	13	14	15	16	18	20	22
90	>365	>365	251	49	27	16	10	5	4	3
85	>365	>365	336	66	36	21	14	7	5	3
80	>365	>365	>365	87	47	28	18	9	6	4
75	>365	>365	>365	117	63	38	24	12	8	5
70	>365	>365	>365	157	85	50	32	16	10	7
65	>365	>365	>365	210	113	67	43	22	13	9
60	>365	>365	>365	278	150	89	57	28	17	11
55	>365	>365	>365	>365	226	134	86	38	22	14
50	>365	>365	>365	>365	339	202	130	50	29	19
45	>365	>365	>365	>365	>365	303	195	66	37	24
40	>365	>365	>365	>365	>365	>365	293	88	48	30
35	>365	>365	>365	>365	>365	>365	>365	115	62	39

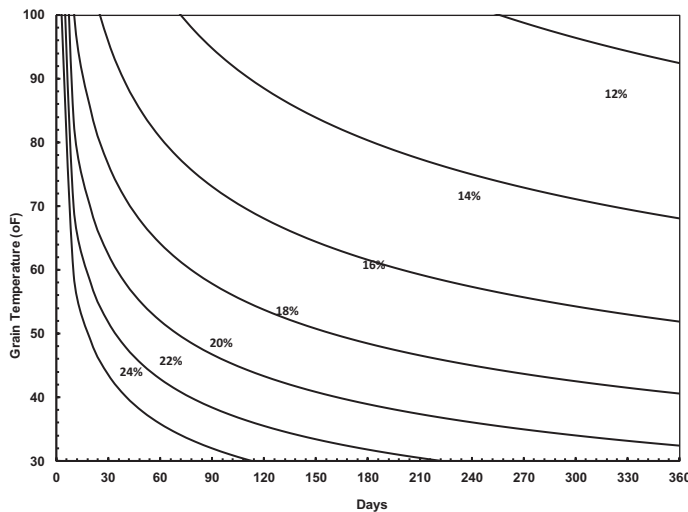
*It should be mentioned that these values assumed about 0.5% dry matter loss.

Table 3. Safe Storage Period for Rice and Wheat (Days).

Rice or Wheat Temperature (°F)	Moisture Content of Rice and Wheat (% Wet Basis)										
	14	15	16	17	18	19	20	21	22	23	24
88	40	20	8	5	3						
81	120	40	10	10	5	5	3				
77	160	40	20	20	10	5	5	5	3		
68	<270	80	40	40	20	10	10	10	5	5	5
59	>270	160	80	60	40	20	20	10	10	10	5
50	>270	>270	160	90	80	50	40	20	15	10	10
41	>270	>270	>270	<270	120	80	50	40	30	20	10

*It should be mentioned that these values assumed about 0.5% dry matter loss.

Figure 1. Safe Storage Period for Corn as Affected by Corn Temperature and Corn Moisture Content.



How to Calculate the Accumulated Safe Storage Period

The following mathematical technique will demonstrate the method of calculating the accumulated safe storage period and determining how many safe storage days are left at a new set of conditions.

- Step 1:** Determine which grain you would like to consider.
- Step 2:** Identify the grain temperature, °F, and moisture content, %.
- Step 3:** Read from the table or chart the safe storage period, days.
- Step 4:** Identify how long the grain has actually been in storage, days.
- Step 5:** Calculate the percentage of storage time by dividing the actual storage time in Step 4 by the chart or table period in Step 3 and multiply by 100: $(\text{Step 4} / \text{Step 3}) \times 100 = \% \text{ of storage time}$.
- Step 6:** Calculate the remaining storage time in percentage by subtracting the percentage found in Step 5 from 100.

Step 7: Calculate the remaining days of safe storage by multiplying the days determined in Step 3 by the percentage found in Step 6 and divide by 100.

Example Scenarios

To explore the technique of calculating the safe storage period under different storage temperatures and moisture contents, the following scenarios are presented and calculations applied.

Scenario 1:

Assume rice was harvested at 23% moisture content and immediately placed in a holding bin equipped with a cooling fan that cools the rice from 77°F to 41°F in 2 days. How long can rice be held at 41°F without excessive deterioration?

- The average storage temperature would be 59°F (add 41 to 77 and divide by 2).
- The safe rice storage period corresponding to rice temperature of 59°F and moisture content of 23% is 10 days (as shown in Table 3).
- The percentage of the duration expended during the cooling period = $2 \text{ days} / 10 \text{ days} \times 100\% = 20.0\%$.
- The remaining safe percentage = $100\% - 20.0\% = 80.0\%$.
- The safe storage period for rice corresponding to temperature of 41°F and moisture content of 23% is 20 days.
- The remaining safe period = $20 \text{ days} \times 80.0 / 100 = 16 \text{ days}$.

Scenario 2:

Assume that corn was harvested at 25% moisture content and set in a truck overnight (12 hours) before unloading. The average temperature in the truck was 70°F, and the corn was then placed in a holding bin equipped with a cooling fan. If the bin was cooled down to 40°F in 3 days, how long can corn be held at 40°F without excessive deterioration?

- The safe corn storage period corresponding to corn temperature of 70°F and moisture content of 25% is 6 days (as shown in Table 1) (conditions of the period stored in the truck).
- The percentage of the duration expended in the truck = $0.5 \text{ day (12 hours)} / 6 \text{ days} \times 100\% = 8.3\%$.
- The remaining safe percentage = $100\% - 8.3\% = 91.7\%$.
- The average storage temperature would be 55°F (add 70 to 40 and divide by 2).
- The safe corn storage period corresponding to corn temperature of 55°F and moisture content of 25% is 14 days (for time spent in the cooling bin).
- The percentage of the duration expended in the cooling bin = $3 \text{ days} / 14 \text{ days} \times 100\% = 21.4\%$.
- The remaining safe percentage = $91.7\% - 21.4\% = 70.3\%$.
- The safe storage period for corn corresponding to corn temperature of 40°F and moisture content of 25% is 48 days.
- The remaining safe period at the final storage conditions = $48 \text{ days} \times 70.3 / 100 = 33 \text{ days}$.

Scenario 3:

Assume that soybeans were harvested at 18% moisture content and set in a truck for 8 hours before unloading. The average temperature in the truck was 80°F, and the soybeans were then placed in a holding bin equipped with a cooling fan. The soybeans were cooled down to 40°F in 4 days. Then, the soybean moisture content was reduced to 16% in 6 days. How long can soybeans be held at 40°F and 16% moisture content without excessive deterioration?

- The safe soybean storage period corresponding to soybean temperature of 80°F and moisture content of 18% is 9 days in the truck (as shown in Table 3).
- The percentage of the duration expended in the truck = $(8 / 24) \text{ day} / 9 \text{ days} \times 100\% = 3.7\%$.
- The remaining safe percentage = $100\% - 3.7\% = 96.3\%$.
- The average storage temperature would be 60°F (add 80 to 40 and divide by 2).
- The safe soybean storage period corresponding to soybean temperature of 60°F and moisture content of 18% is 28 days (time in cooling bin).
- The percentage of the duration expended in the cooling bin = $4 \text{ days} / 28 \text{ days} \times 100\% = 14.3\%$.

- The remaining safe percentage after cooling = $96.3\% - 14.3\% = 82.0\%$.
- The safe storage period for soybeans corresponding to soybean temperature of 40°F and moisture content of 18% is 88 days.
- The percentage of the duration expended during the drying period = $6 \text{ days} / 88 \text{ days} \times 100\% = 6.8\%$.
- The remaining safe percentage after drying = $82.0\% - 6.8\% = 75.2\%$.
- The safe soybean storage period corresponding to soybean temperature of 40°F and moisture content of 16% is 293 days.
- The remaining safe period = $293 \text{ days} \times 75.2 / 100 = 220 \text{ days}$.

It should be mentioned that this method could be used for any stored grain product as long as the storage tables or graphs for that specific product are used. Other storage tables or graphs could be downloaded through the Extension websites.

Resources for Further Information

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