



Specialist information for soy producers and processors

Storage of soybeans

The challenge: Avoiding shell injuries

With regard to maintaining germination capacity, soybeans are considered to have poor storage properties (Table 1). This is mainly because the seed coat of soybeans is very sensitive. However, there are differences between the varieties.

Large-grained varieties with a high thousand grain weight (TGW), such as the tofu variety PRIMUS, are often more sensitive than small-grained varieties such as MERLIN. Mechanical stress combined with low grain moisture can easily damage soybeans. These range from invisible injuries of the seed coat (micro cracks) to visible cracks, flaking of the seed coat and breakage of the soybeans. Figure 1 shows soybeans with distinct cracks in the seed coat. As a consequence of the injuries, air penetrates into the seed interior and leads to fat spoilage and loss of germination capacity. Critical process steps where breakage and shell injuries can occur are combine harvest, conveyors, drop heights and drying.

Good soy storage therefore begins with the upstream processes, where everything must be done to avoid shell damage.

Table 1: Storage abilities of seeds of selected crop-plants (from Kruse, 2008, shortened)

Storability	Species
Good	Lentils, Vetchlings, Flax, Vetches, English bean
Average	Peas, Wheat, Barley, Rye, Oats, Corn, Rape
Bad	Soybean , Sunflower



Figure 1: Shell cracks in soybeans



Combine them gently!

Only whole soybeans free from damaged shells can be stored adequately. Therefore, successful storage of soy begins with the harvesting process. Ideally, the threshing moisture should be situated between 13 and 16%. If soybeans are threshed too dry, the proportion of broken grains and grains with shell damage increases sharply. Further information on the gentle threshing of soya can be found on the website of the German Soy Promotion Ring (www.sojaforderung.de | Deutscher Sojaförderring e.V.). Especially recommendable is the short explanatory video "[Soja richtig dreschen](#)".

Select adapted conveyor systems!

Conveyor systems stress soy in different ways. Also here, the drier the soy, the more sensitive it is. If the use of screw conveyors is unavoidable, e.g. when emptying the grain tank of the combine harvester, they should only be operated under full load and at low speed to avoid breakage and shell damage. Chain conveyors are better, conveyor belts the best solution (see also Table 2).

Table 2: Risk of soybean shell injuries due to various conveyor systems (own presentation)

Conveyor system	Danger from shell injuries
Spiral conv	High, especially when under partial load
Bucket elevator	Medium. Drive slower than for cereals and maize
Chain conveyor	Medium -- low
Pneumatic conveyor	High for wrong settings. Strongly dependent on the conveying speed and the conveying path
Belt conveyor	extremely low

Dry gently!

Soybeans are very sensitive to high temperatures in the drying process. Excessively heated drying air quickly leads to shell injuries and breakage. If soybeans for seed production or food are dried gently, the relative humidity of the drying air should not fall below 55% (see also Table 3). This means drying with outside air (cold air) or, if necessary, slight heated air.

The grain temperature should not exceed 37°C. In general, high air rates are just as important as the heating of the drying air.

Table 3: Shell damage and breakage during soybean drying as a function of the relative humidity of the drying air (according to Hellevang, K., 2012)

Rel. air humidity Drying air	Percentage Damaged shells	Percentage breakage
50%	5%	0%
40%	15%	0%
30%	30%	0%
20%	50%	8%
10%	70%	25%

Control of shell injuries with the quick soaking test

With the quick [soaking test](#) (see www.sojaforderung.de) shell injuries can be made visible and thus the processes can be controlled before storage. After 10 minutes in water, soybeans with shell injuries inflate like balloons. Undamaged beans on the other hand do not change their shape. Compare also Fig. 2.



Figure 2: Quick soak test. After 10 minutes in water, soybeans with shell injuries inflate like balloons (top left in the picture).

Correct storage conditions: The play with temperature and humidity

To protect soybeans in storage from mold and pests, temperature and humidity must be controlled. The longer the storage time, the drier the soybeans must be. The following rules of thumb apply:

Grain moisture	Storage period
14%	6 months (cold storage at 6 - 8 °C)
13%	6 - 9 months (during winter)
12%	1 year
11%	1 - 3 years

The mentioned grain moisture contents of 11 - 14% are clearly lower than the recommended values for cereals or maize. Since soybean seeds contain a lot of oil, the same relative humidity and temperature results in a lower seed moisture content than seeds containing less fat and more carbohydrates:

Equilibrium humidity at 21 °C and 60% relative humidity (according to various authors)

Wheat	13.3%
Maize	12.8%
Soybeans	10.7%
Rapeseed	7.0%

Table 4 shows the equilibrium moisture content of soybeans as a function of temperature and relative humidity. At 21°C and a relative humidity of 60%, for example, an equilibrium moisture content of 10.7% is reached in the soybean grain. If soybeans are left exposed in heated interiors during winter (21 °C, 50% relative humidity), a grain moisture content

Table 4: Equilibrium moisture content (%) of soybeans as a function of temperature and relative humidity.

Temperature	Relative air humidity					
	40%	50%	60%	65%	70%	80%
1.7 °C	7.8	9.4	11.5	12.8	14.4	19.1
4.4 °C	7.7	9.3	11.3	12.6	14.2	18.9
10 °C	7.6	9.1	11.1	12.4	14.0	18.6
16 °C	7.4	8.9	10.9	12.2	13.7	18.3
21 °C	7.3	8.8	10.7	11.9	13.5	17.9

of less than 9% is reached. This example illustrates why soy samples must be sealed airtight immediately if they are to reflect the true conditions in the storage. This applies even when measuring humidity in the laboratory.

To protect soybeans from mold growth in storage, the **relative humidity** should be **below 65%**.

In addition to soybean moisture, the storage temperature has a decisive influence on the storage abilities. This relationship is important for the stabilization of moist batches during harvest. Soybeans with a harvest moisture content of 19% may well be stored for a month before drying if the grain temperature is rapidly cooled down to 10°C. For details see Table 5. The above mentioned 13% grain moisture for a storage of 6-9 months does also only apply if the grain temperature is 16 °C or less during storage.

Table 5: Approximate, tolerable storage period of soybeans in days (after Hellevang, K., 2012)

grain-moisture	Grain temperature					
	--1 °C	4 °C	10 °C	16 °C	21 °C	27 °C
11%	> 300	> 300	> 300	> 300	200	140
12%	> 300	> 300	> 300	240	125	70
13%	> 300	> 300	230	120	70	40
14%	> 300	280	130	75	45	20
15%	> 300	200	90	50	30	15
16%	>300	140	70	35	20	10
17%	>300	90	50	25	14	7
19%	190	60	30	15	8	3
21%	130	40	15	10	6	2
23%	90	35	12	8	5	2
25%	70	30	10	7	4	2

Moisture measurement for soy: only with acclimatized samples

Even when using moisture meters with automatic temperature correction, soy samples should not be measured below 5 °C. If cold samples are measured in warm rooms, condensation water can falsify the measurement. It should also be noted that soybeans can be drier just below the grain surface after rapid drying than in the inside. Hence, when using moisture meters for whole beans, measuring errors may occur. **It is therefore generally recommended that soy samples are first acclimatized in a closed box for 6 - 12 hours and only then the measurement is carried out.**

Ventilation and temperature control

After harvesting, soybeans should be well ventilated to compensate for temperature differences and prevent condensation of moisture. As with the ventilation of other crops, the temperature difference between fresh air (outside air) and soybeans as well as the relative humidity of the fresh air must be taken into account. The temperatures in the various silo zones must be permanently monitored even after drying. Areas with increased humidity can quickly develop into so-called hot spots. If you notice a sudden sharp rise in temperature, you must immediately intervene with ventilation and cooling.

Storage pests

International soy literature describes about 55 species of insects in soy storages. Stockists in Central Europe, on the other hand, indicate that insect pests play practically no role in soy storage. Only flour moths have to be taken into account when soybeans are stored in bigbags. The most important preventive measures against harmful insects are well-cleaned storage silos, cool storage temperatures (10 - 12 °C) and dry soybeans with 12 - 13% residual moisture.

Fungi / Mycotoxins

Soybeans can be infected by various fungi. However, it is remarkable that, in contrast to cereals or maize, no or hardly any mycotoxins are formed.

In our own investigations we have found that even under very unfavorable conditions (humid and warm

weather in September and October and a very late harvest) we could not detect mycotoxins (aflatoxins, ochratoxin A, DON, ZEA) in harvest samples.

Tips from experienced soy stockists

- Treat soybeans gently, otherwise breakage and abrasion will occur
- The elevator should be driven slower than with grain / corn, because beans can easily get caught in the V-belt pulleys
- Clean out breakage and dockage before storage
- Dry carefully - soy quickly overdries
- Only beans that have been dried under controlled conditions and have optimum residual moisture of 12 - 13% are suitable for long-term storage.
- Equipping silo corners with smooth sheets
- Avoid high drop heights
- Ventilate abundantly
- Monitor temperature continually (hotspots!)
- Pay attention to deviating odors
- Check the underside of the silo roofs for condensation water
- Store soybeans protected from light. In bigbags soy can easily be infested by moths.

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