# Media Release

*Performance test result by Dr. Anna N. Vega, 16.05.2017*

## Bühler Drying System for Paddy proven to be gentle, barely creating brokens


Bühler AG
CH-9240 Uzwil, Switzerland
T +41 71 955 11 11
F +41 71 955 38 51
www.buhlergroup.com

**Quick content summary**

- A performance test of a three pass paddy dryer was carried out by an independent third party at a customer site in Chai Nat / Thailand
- The measurements showed that the milling quality of paddy was reduced by only 1-2% from intake to the dryer outlet using the Bühler system
- A five pass local dryer running with the same raw material led to an increase in brokens of 5-10%
- The study highlights the need for tempering and product temperature control in order to prevent quality losses in Paddy drying
- The above-average performance of the Bühler drying system as well as the excellent outlet quality got confirmed

## Introduction in rice drying

In contrast to other crops, rice is a difficult to handle cereal, because most of it goes to human consumption (Iguaz and Virseda 2007). As the whole grain is the preferred form, which consumers demand, broken rice has typically only half the market value of head rice (Thompson and Mutters, 2006).

Whenever ambient conditions change and moisture sorption or desorption processes are induced, the kernel surface is in equilibrium with the surrounding conditions after short time. The moisture at the center of the kernel however changes very slowly causing moisture gradients within the kernel that come along with compressive and tensile stresses which, if exceeding material strength, lead to material failure. It is therefore crucial to minimize moisture gradients during any process step.

Due to its perishable nature, rice usually has to be dried in order to prevent qualitative and quantitative losses. However, because of moisture changes related to this process the final product quality is especially sensitive to the mode of drying (Iguaz and Virseda 2007). Finding the best drying process for rice is vital in order to get a product of maximum quality, although it is challenging because of the much higher susceptibility to breakage found in rice when compared to other grains. Traditional air drying methods aren’t best suited because of their long drying times and high pest risks. Recirculation batch dryers may increase kernel breakage because of the huge amount of recirculation, causing additional stresses. Continuous drying systems might be the solution and offer the additional benefit of supplying a constant output to the subsequent milling process. Such drying systems usually comprise of up to three dryers and temper bins in between drying passes, holding the rice for a certain period of time to allow moisture content gradients within kernels to subside and consequently to minimize stresses and resulting fissuring. The tempering phases also eliminate moisture variations of raw rice kernels that are usually found during the harvesting period (Chau and Kunze 1982).

It could be shown by various authors, that drying conditions, drying time and tempering duration have a significant effect on head rice yield (Nasrnia et al. 2010). In continuous drying, inlet temperatures in the range of 40-150°C do not affect the quality of cooked rice and the milling quality of paddy is well maintained (Tirawanichakul et al. 2004). Furthermore it was found, that high amounts of water can be removed during the first stage of drying, if sufficient tempering time is assured (Fendley and Siebenmorgen 2002) and high air temperatures can be applied in the first drying pass (Nasrnia et al. 2010).

The aim of this study was to endorse the good performance of the Bühler drying system and compare the product quality obtained with the results of a typical competitor dryer found in Southeast Asia.

## Bühler Grain Drying Technology

Bühler drying technology represents state of the art continuous flow drying, which offers a variety of advantages when compared to conventional batch systems, where a dusty environment is created and the broken percentage is high due to constant recirculation. However, the main problem of batch drying systems is the unevenness in moisture content after the drying process. Because of the lack of possibility to adjust the dwell time within one batch, it´s not possible for the operator to react on different incoming moisture contents, whereas the dwell times in a continuous system can always be adjusted. The loss in drying time while the batch is being loaded or unloaded and the increased need for supervision and labor also have to be considered. The Bühler process in contrast is carried out in several stages, allowing the paddy to rest in between the drying steps in order to prevent breakage due to moisture inhomogeneity.

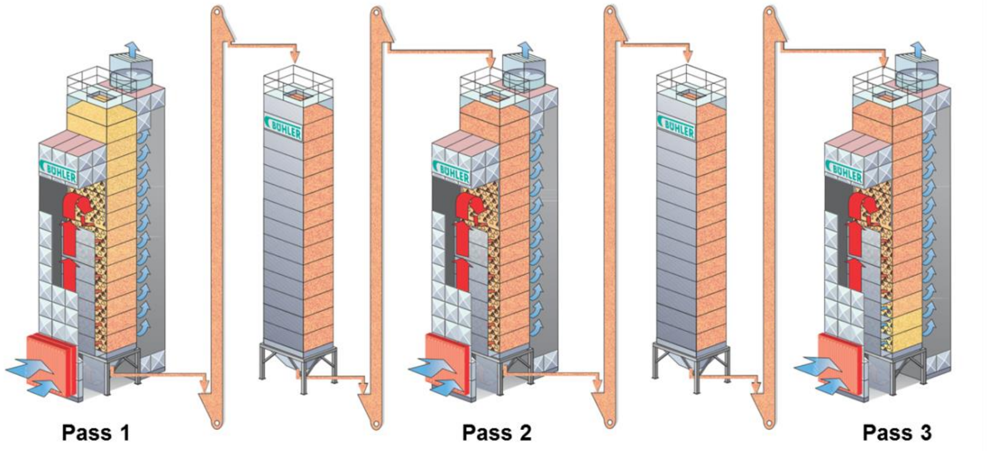



*Fig. 1 Bühler three-pass solution for paddy drying without dedusting*

Variations in moisture are eliminated in the tempering bin that, along with the special duct arrangement and separation of product flow, leads to a very uniform drying result. Mellmann et al. (2016) just recently confirmed the advantage of a diagonal duct arrangement over the traditional horizontal one when it comes to homogenous moisture distribution in the dryer outlet. The diagonal duct arrangement and the resulting permanent alternation of air flow direction in EcoDryTM dryers furthermore significantly reduce thermal stress to paddy rice and guarantee an absolute uniform air distribution and velocity. All these advantages lead to an extremely fast, but nevertheless gentle drying process with a reduction of losses and breakage through stress cracking.

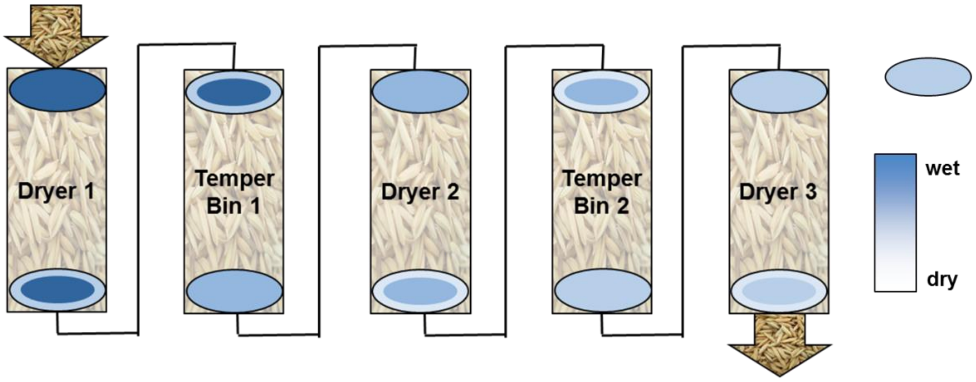



*Fig. 2 Moisture distribution within the product during the drying process*

The possibility of up to 25% less energy expenses for Bühler dryers is given by the diagonal duct arrangement, a product flow separation in the middle of the column, the design of the discharge system, the optional moisture control system, the adapted process control (such as the adjustment of the dwell times), the fitting dimensioning of the dryer, the appropriate fans and heating unit as well as the insulation of the dryers.

Bühler dryers allow to continuously dry large quantities of grain without stopping, are designed for direct or indirect heating and are low in operating costs. Even moist dust can be removed by highly efficient central separators. The formation of residues is prevented thanks to a self-cleaning effect provided by jolting emptying that also guarantees consistent dwell times and an uniform mass flow as well as discharge in all drying and tempering steps.

The advantage of Bühler technology is the continuous mass flow even in the tempering bins while competitor solutions lead to an uneven discharge and residues within the bin. Besides a two pass as well as three pass drying solution for raw paddy, comprised of two or three continuous-flow column dryers and one or two tempering bins in between, a three pass solution is also available to dry parboiled paddy. Due to the high moisture contents even higher air temperatures can be applied without deteriorating product quality.

## Scope of the performance test

The performance test was carried out by Assist. Professor Jaitip Wanitchang, Ph.D. and Assist. Professor Padungsak Wanitchang, Ph.D. from the Rajamangala University of Technology Tawan-ok. The objective of the performance test was to investigate the quality of rice before and after the drying process on the Bühler drying system as well as on a five pass local drying system, processing the same raw material. The grain moisture content as well as the product temperature were measured every hour during the test runs. The drying conditions, the grain flow speed and the energy consumption were monitored as well.

## Performance test – Setup

The grain dryer performance tests were carried out from March 27th to March 29th 2017 and from April 5th to April 6th 2017. The product moisture contents were measured using a resistance type moisture meter (OGA Model TA-5). The drying and grain temperatures were taken from the plant sensors installed inside the dryers.

For the milling quality evaluation the standard method used at Rajamangala University of Technology Tawan-ok was applied. If the moisture content of the sample was higher than 14% (e.g. product from dryer 1 inlet) it was dried in a testing dryer before evaluation. 250g of each sample were husked 2-3 times on a locally made husking machine (double roll type) until 100% husking was achieved. The product was weighed afterwards and also after all following process steps to determine the respective percentages of brown rice, white rice and broken rice. The brown rice was then milled on a Satake abrasive type test mill (TM-05). The broken rice was subsequently separated from the head rice using a length grader. The color of the head rice was measured using a Satake milling meter.

The customer in Chai Nat / Thailand is located in an area where paddy is grown all year long. The customer produces milled rice as well as milled parboiled rice. The site comprises two dryer lines, a parboiled rice plant, a rice mill and storage facilities. The capacity of the dryer line provided by Bühler is 1,000 tons per day. The customer purchases around 20,000 tons of freshly harvested raw paddy per month, mainly from local farmers. The moisture content of paddy received during the test varied from 21.7% to 27.2%. The average quality of raw paddy determined by standard method was 75% brown rice, 58.7% head rice (brown), 65.5% milled rice and 37.8% head rice (milled), the quality obtained in April was slightly better (75.2% / 60.8% / 66.2% / 40.9%).

The customer receives and dries freshly harvested paddy day-by-day. Most of the paddy is loaded into aerated silos where the moisture content is reduced by about 1-3% before the drying process. The moisture content in the inlet to dryer 1 is thus lower than the moisture content measured upon reception.

## Results – Drying Kinetics

Within the Bühler drying system, all temperatures, including hot air, exhaust air and product temperature are monitored. In the competitor system in contrast, only the hot air temperature is controlled and monitored. The grain moisture in the outlets of the Bühler line (dryer 1, dryer 2 and dryer 3), as well as in the outlet of the competitor system were measured manually every hour.

At the beginning of the first set of tests the dryer was running in three pass mode as originally designed. However, the inlet moisture content was already pretty low (~18-21%) and it was suggested to run the dryer in two pass mode, bypassing dryer 1 and temper bin 1. Figure 3 shows the drying curve for two different measurements during the first performance test campaign in three pass mode.

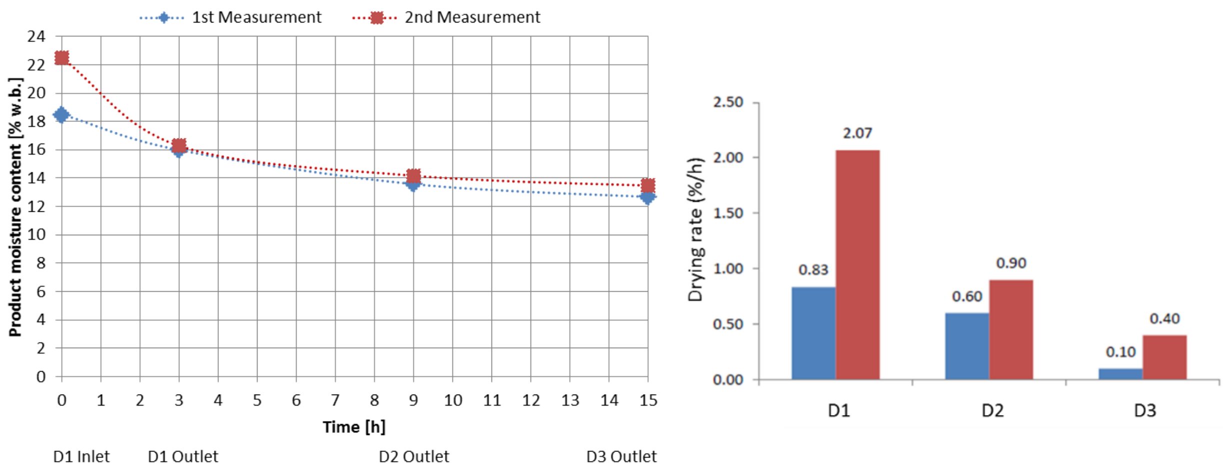



*Fig. 3 Drying curve for three pass drying (left) and the corresponding drying rates (right)*

The set points for hot air temperature were 55°C (D1) and 50°C (D2 and D3). The drying time as well as tempering time were around 3 hours per pass. It is clearly visible that the drying rate was higher for the higher inlet moisture content. The drying and resulting parameters and values for the second set of tests (two pass mode) can be found in table 1.

| Date | Time | Dryer | Heated air (°C) | Input MC(%) | MC out (%) | Drying rate (%/h) |
|---|---|---|---|---|---|---|
| April,1 | 08:00-19:00 | 2 | 64.0 | 19.8 | 17.2 | 0.9 |
| | | 3 | 59.2 | | 14.1 | 1.0 |
| | 20:00-07:00 | 2 | 60.5 | 19.1 | 17.7 | 0.4 |
| | | 3 | 59.6 | | 14.3 | 1.1 |
| April,2 | 08:00-19:00 | 2 | 68.8 | 19.9 | 17.1 | 0.9 |
| | | 3 | 64.9 | | 13.9 | 1.1 |
| | 20:00-07:00 | 2 | 67.8 | 19.5 | 17.5 | 0.7 |
| | | 3 | 61.3 | | 13.9 | 1.2 |
| April,3 | 08:00-19:00 | 2 | 74.7 | 20.3 | 17.2 | 1.0 |
| | | 3 | 65.3 | | 13.8 | 1.1 |
| | 20:00-07:00 | 2 | 66.8 | 21.1 | 18.0 | 1.0 |
| | | 3 | 62.6 | | 14.2 | 1.3 |
| April,4 | 08:00-19:00 | 2 | 72.9 | 20.5 | 16.8 | 1.2 |
| | | 3 | 66.6 | | 13.6 | 1.0 |
| | 20:00-07:00 | 2 | 68.6 | 20.3 | 17.8 | 0.8 |
| | | 3 | 69.2 | | 13.9 | 1.3 |
| April,5 | 08:00-19:00 | 2 | 69.9 | 20.8 | 17.3 | 1.1 |
| | | 3 | 64.7 | | 14.5 | 0.9 |
| | 20:00-07:00 | 2 | 70.6 | 20.3 | 17.8 | 0.8 |
| | | 3 | 67.6 | | 14.0 | 1.3 |

*Tab. 1 Hot air temperature, moisture contents and drying rates for two pass drying*

When looking at the moisture contents and drying rates, it is obvious that the final moisture content of 13-14% can be reached by drying in two pass mode as well. It can be concluded that it is beneficial in terms of energy consumption to use the dryers in two pass mode if the inlet moisture content is at around 20-22% or lower.

## Results – Milling quality

For the milling quality evaluation paddy samples were taken every hour from the intake and the outlets of dryer 1 to 3. The samples from the intake as well as dryer 1 and dryer 2 outlet were dried in the test dryer before evaluation. The results are shown in table 2.

| | | 27-29 March | | | 5-6 April | |
|---|---|---|---|---|---|---|
| Condition | Quality | 3 pass | 2 pass | Intake | 2 pass | Intake |
| Dryer1 | Brown rice (%) | 75.5 | | | | |
| | Milled (%) | 68.3 | | | | |
| | Bran (%) | 7.2 | | | | |
| | HRY (%) | 44.8 | | | | |
| | Broken (%) | 23.4 | | | | |
| Dryer2 | Brown rice (%) | 76.0 | 75.3 | | 75.7 | |
| | Milled (%) | 68.2 | 67.9 | | 67.8 | |
| | Bran (%) | 7.8 | 7.4 | | 7.9 | |
| | HRY (%) | 45.8 | 47.2 | | 43.6 | |
| | Broken (%) | 22.4 | 20.7 | | 24.2 | |
| Dryer3 | Brown rice (%) | 76.3 | 75.0 | 74.2 | 75.7 | 75 |
| | Milled (%) | 68.3 | 67.2 | 65.8 | 68.0 | 66 |
| | Bran (%) | 8.0 | 7.8 | 8.4 | 7.6 | 9 |
| | HRY (%) | 46.7 | 46.8 | 47.0 | 50.6 | 42.6 |
| | Broken (%) | 21.6 | 20.5 | 18.8 | 17.4 | 23.4 |

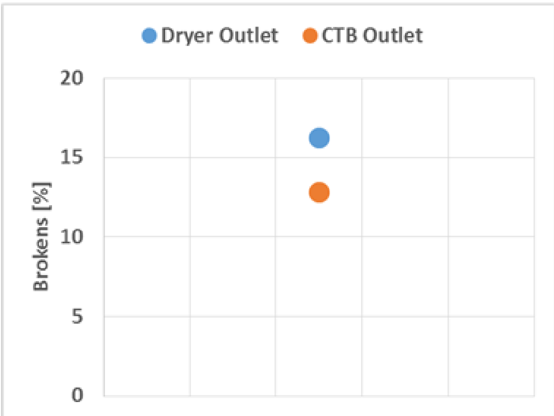
*Tab. 2 Milling quality determined using Rajamangala University of Technology Tawan-ok standard*

The head rice yield for D1 to D3 obtained during the first test in three pass mode (March 27th-29th) was 44.8, 45.8 and 46.7%, respectively and 47.2% (D2) and 46.8% (D3) in two pass mode. The inlet head rice yield was 47% during this first set of measurements. The resulting head rice yield from two and three pass mode did not differ significantly making the use of the two pass mode a viable alternative to three pass mode for low moisture paddy with the additional benefit of lower energy consumption.

For the second set of tests (April 5th-April 6th) the resulting head rice yield showed an increase from 43.6% in dryer 2 outlet to 50.6% in dryer 3 outlet, with an intake head rice yield of only 42.6%. This increase in head rice yield can be explained by a slightly different milling degree when comparing the different samples (table 3). The milling degree measured using the Satake milling meter was 108 for the intake sample but 97.5 for the sample taken from dryer 3 outlet, showing that this high difference was due to the difference in bran removal.

| Satake Milling Meter | | Dryer 1 | Dryer2 | Dryer3 | Intake |
|---|---|---|---|---|---|
| 1 st test | Whiteness | 42.0 | 41.9 | 42.7 | 42.1 |
| | Transparency | 2.7 | 2.7 | 2.7 | 2.7 |
| | Milling degree | 103.7 | 103.0 | 106.4 | 104.0 |
| 2nd test | Whiteness | | 41.7 | 41.0 | 42.6 |
| | Transparency | | 2.5 | 2.5 | 2.9 |
| | Milling degree | | 100.5 | 97.5 | 108.0 |

*Tab. 3 Color and milling degree of rice samples*




The head rice yield obtained using the Bühler dryer line decreased about 2-3% (March 27th-29th) and 1-2% (April 5th-6th) from intake to dryer 3 outlet. This value improved during the second set of trials due to an adaption of the drying parameters. At first the product temperatures in dryer 3 were slightly too high (45-50°C) and the operators were asked to adjust the product temperature to a maximum of 40°C by lowering the hot air temperature accordingly. This adjustment usually is done automatically but there were problems due to a damaged temperature sensor during the first set of tests.

*Fig. 4 Influence of tempering on brokens*

An additional test was carried out in order to further determine the influence of tempering on product quality during the second set of experiments. Paddy samples were taken after dryer 2 and temper bin 2 outlet, they were dried in a test dryer and milled according to the standard procedure. The only difference between the two samples was the three hour tempering: one sample was tempered the other not. The result of this test can be seen in figure 4. The tempering step led to a reduction of brokens of about 3.5% when compared to the value of the sample that was taken from dryer 2 outlet. This result clearly highlights the need for tempering.

The milling quality determination was carried out for the local (competitor) dryer line as well. This dryer line consists of 5 column dryers and the product runs through all five dryers without tempering steps. Table 4 shows the outlet moisture contents of the 5 columns.

| | 17/03 | 18/03 | 21/03 | 22/03 | 23/03 | 24/03 |
|---|---|---|---|---|---|---|
| Dryer1 | 20.3 | 18.8 | 15.8 | 15.9 | 16.1 | 16.0 |
| Dryer2 | 18.0 | 17.1 | 15.1 | 15.5 | 15.8 | 15.6 |
| Dryer3 | 15.3 | | | | 15.5 | 15.4 |
| Dryer4 | 16.0 | 14.5 | 14.2 | 14.7 | 15.2 | 15.1 |
| Dryer5 | 13.6 | 13.2 | 14.4 | 14.3 | 14.6 | 14.6 |

*Tab. 4 Moisture contents of paddy in local dryer*

The resulting milling quality obtained with the local dryer is shown in table 5. The head rice yield was about 5-10% lower when compared to the inlet quality.

| Date | Quality | Dryer | Intake | Date | Quality | Dryer | Intake |
|---|---|---|---|---|---|---|---|
| 17/3 | MC (%) | 13.3 | 13.1 | 22/3 | MC (%) | 14.0 | 13.6 |
| | Brown rice (%) | 75.6 | 76.0 | | Brown rice (%) | 75.0 | 75.0 |
| | Head brown rice (%) | 56.9 | 56.0 | | Head brown rice (%) | 58.8 | 56.0 |
| | Milled rice (%) | 65.5 | 67.0 | | Milled rice (%) | 65.3 | 66.0 |
| | HRY (%) | 33.6 | 38.0 | | HRY (%) | 31.7 | 37.0 |
| | Bran (%) | 10.1 | 9.0 | | Bran (%) | 9.8 | 9.0 |
| | Broken rice (%) | 31.8 | 29.0 | | Broken rice (%) | 33.6 | 29.0 |
| 18/3 | MC (%) | 13.0 | 13.6 | 23/3 | MC (%) | 14.3 | 13.6 |
| | Brown rice (%) | 73.8 | 76.0 | | Brown rice (%) | 74.5 | 75.0 |
| | Head brown rice (%) | 55.0 | 56.0 | | Head brown rice (%) | 56.2 | 60.0 |
| | Milled rice (%) | 64.8 | 67.0 | | Milled rice (%) | 65.1 | 66.0 |
| | HRY (%) | 29.9 | 38.0 | | HRY (%) | 29.3 | 41.0 |
| | Bran (%) | 9.0 | 9.0 | | Bran (%) | 9.4 | 9.0 |
| | Broken rice (%) | 34.9 | 29.0 | | Broken rice (%) | 35.9 | 25.0 |
| 21/3 | MC (%) | 13.9 | 13.6 | 24/3 | MC (%) | 14.4 | 12.1 |
| | Brown rice (%) | 75.5 | 75.0 | | Brown rice (%) | 74.7 | 74.6 |
| | Head brown rice (%) | 58.9 | 55.0 | | Head brown rice (%) | 60.1 | 56.8 |
| | Milled rice (%) | 65.8 | 66.0 | | Milled rice (%) | 65.6 | 64.8 |
| | HRY (%) | 31.8 | 37.0 | | HRY (%) | 33.1 | 38.8 |
| | Bran (%) | 9.8 | 9.0 | | Bran (%) | 9.1 | 9.8 |
| | Broken rice (%) | 33.9 | 29.0 | | Broken rice (%) | 32.5 | 26.0 |

*Tab. 5 Milling quality of paddy dried in local dryer*

The local dryer also showed higher fluctuations in outlet moisture content (13.9 ± 0.7%) when compared to the outlet moisture content obtained with the Bühler dryer line (14 ± 0.4%).

## Conclusions

Drying Paddy with the Bühler dryer line led to an increase of brokens of as low as 1-2% when operated correctly. The local dryer in contrast augmented the number of brokens about 5-10%. This highlights the need for tempering steps in between the drying steps to reduce stresses within the kernels and prevent product quality losses due to breakage. An additional test, taking a closer look at the tempering step, further underpinned this assumption.

The results also showed, that the quality of low moisture paddy is not altered when dried in two passes instead of three passes. Besides the option for a two pass dryer already offered to customers processing low moisture paddy, all three pass raw paddy dryers used in countries with high fluctuations in incoming moisture content, where the inlet moisture content sometimes is pretty low, should have the option to bypass dryer 1 and temper bin 1 in order to save energy and process time.

## References

Chau, N. N., and O R Kunze (1982), Moisture content variations among harvested rice grains. Trans. ASAE 25(4): 1037-1040.

Fendley, J. W., & Siebenmorgen, T. J. (2002). Effect of drying and tempering rice using a continuous drying procedure. AAES Research Series, 504, 382-389.

Iguaz, A., and Virseda, P. (2007). Moisture desorption isotherms of rough rice at high temperatures. J Food Eng, 79(3), 794-802.

Mellmann, J., Scaar, H., Weigler, F., Franke, G. (2016), Effect of the air-duct arrangement on homogeneity of drying in mixed-flow grain dryers. International Drying Symposium (IDS) 2016, 07.08.-10.08.2016 Gifu, Japan

Nasrnia, E., Sadeghi, M. and Masoumi A. A. (2010). Effect of Drying and Tempering Conditions on Milling Quality of Rough Rice. CIGR Congress, Québec City, Canada June 13-17, 2010

Thompson, J. F., and R. G. Mutters (2006), Effect of weather and rice moisture at harvest on milling quality of California medium-grain rice. Trans. ASABE 49(2): 435-440.

Tirawanichakul, S., Prachayawarakorn, S., Varanyanond, W., Tungtrakul, P., & Soponronnarit, S. (2004). Effect of fluidized bed drying temperature on various quality attributes of paddy. Drying Technology, 22(7), 1731-1754.

**Media contact:**
Martina Eckerle
Marketing Communication Specialist
Eichstätter Strasse 49
DE-92339 Beilngries
Phone: +49 8461 701 129
E-mail: martina.eckerle@buhlergroup.com

**About Bühler**

Every day, billions of people come into contact with Bühler technologies to cover their basic needs for food and mobility. We strive for innovations for a better world, with a special focus on healthy, safe, and sustainable solutions. We contribute significantly to feeding the world’s population, while setting the focus on food security and safety. Our solutions and technologies enable efficient and clean mobility.

We are a leader in processing grains, rice, cocoa, coffee, and other raw materials. Also, we are a leading solution provider of die-casting and surface-coating technologies in high-volume application areas, such as automotive, optics, and inks. As a leading technology group, Bühler invests up to 5% of its turnover every year in Research & Development. In 2016, its 10,640 employees in over 140 countries generated a turnover of CHF 2.45 billion. The globally active Swiss family-owned company Bühler is particularly committed to sustainability.

We want our customers to be successful. We want every human being to have access to healthy food. We want to protect the climate with energy-efficient cars, buildings, and machinery.