Agronomy Research **11** (1), 117–124, 2013

Influence of humidity on the quality of baled hops at grower

L. Vent* and A. Rybka

Czech University of Life Sciences Prague, Faculty of Engineering, Kamýcká 129, Praha 6 – Suchdol, Postcode 16521, Czech Republic;
*Correspondence: lvent@tf.czu.cz

Abstract. Nowadays, in most of cases cured hops are pressed into square bales instead of round bales. The specific weight of packaged hop is about 22% higher in the square bale and intensity of moistening of packaged hop is very important in this case. There is an increased risk of dampening of hops in the square bale when the moistening intensity is too high. In the opposite case is increased risk of destruction of hop cones due to low moistening intensity. The aim of this work was find out the influence of the intensity of moistening of hops before pressing into the square bales on the development of humidity and quality of hops after pressing during storage at the grower. There were pressed square bales with humidity of hops from 9.2% to 16.2%. The square bales with hop's humidity 9–10% represented a dry variant, square bales with hop's humidity 11–12% represented an normal variant and square bales with hop's humidity 13% and higher represented a wet variant. The square bales were stored on the first floor of the drying machine house at the grower. The range of storage temperature was from 7 to 40 °C. All square bales were of the same condition. Humidity of the hops was monitored during 10 days. At the end of the measurement, there was carried out a laboratory analysis of hops of all square bales. Samples were analysed for content of α – bitter acid and destruction of hop cones. During storage, the humidity of wet variant dropped from 14.2 to 12.7% and the humidity of dry variant increased from 9.37 to 11.1%. The destruction of hop cones was highest at dry variant (28%). On the contrary the lowest value was at normal variant (12.3%) and it is about 43% less. However, the dependence of destruction of hop cones by humidity at a significant level $\alpha = 0.05$ has not been proven. There was no proven differences of content of α – bitter acid between all three variants. The highest value 4.9% was at wet variant. We found out a direct dependence of content of α – bitter acid on the humidity of hops in this case. The results of content of α – bitter and destruction of hop cones show that the best one was normal variant with starting humidity from 11.2 to 11.6%.

Key words: *hops, moistening, humidity, storage, bales*.

INTRODUCTION

Originally, cured hop is pressed into the round bales with diameter 0.6 m and height 1.2 m. But round bales are replaced with square bales in most cases nowadays. Square bales are pressed by the fully automated mobile HL-60/M square bale press which presses cured hops at a constant pressure. The square bale has measurements 0.6 x 0.6 x 1.2 m (http://chmelarstvi-zavodmechanizace.cz/EN/hranolovy-lis.html.Accessed 2012). The main advantage of square bales is better use of space during transport and storage. Next advantage is less volume of packaged hops. The volume of the round bale is for about 0.635 m^3 and weight is approximately 60 kg. The specific weight of packaged hops is 94.5 kg m^{-3} in this case. The volume of square bale is about 0.43 m^3 and weight is approximately 50 kg. The specific weight of packaged hops is 115,7kg m^{-3} in this case. Because of higher pressure and higher specific weight there is about a 22% increase risk of steam up of packaged hops. High humidity of packaged hops leads to an increase of temperature and surface humidity of hop cones. This phenomenon is called damping (Rybáček et al., 1980). This process is increased by damage of hop cones during mechanised hop picking. During increasing of the intensity of respiration is increased consumption of oxygen. The oxygen is extract by the intramolecular decomposition of organic substances (Vent et al., 1963). In packaged hops with high content of water (above 15%), there is a danger of degradation of hops. In larger volume there is a danger of autoignition (Krofta, 2008). The temperature and humidity of stored hops is higher than temperature and humidity of free distributed hops. This fact is caused by increase of intensity of respiration of hop cones and releasing of H_2O and CO_2 (Vent, 2012). The prevention of damping is possible with lower humidity of pressed hops. But too low content of water of packaged hops causes high destruction of hop cones. Due to low humidity of packaged hops, hop cones become fragile and they are more likely to crumble during mechanical processes. Too low humidity of small hop cones can be caused by their different size (Krofta, 2008). When hops are overdried, their quality declines and also moistening before baling becomes more difficult (Krofta, 2008).

METHODS AND MATERIALS

The measurement took place in August 2012 during hop harvest in the PSH 750 hop-drying machine at the CHMEL-VENT company. For each variant were prepared three bales. Square bales are pressed by the fully automated mobile HL-60/M square bale press which presses cured hops at a constant pressure. The humidity of hops was modified by the setup of the air condition system of the drying machine. There were pressed bales with humidity of hops from 9.2% to 16.2%. The square bales with hop's humidity 9–10% represented a dry variant, bales with hop's humidity 11–12% represented a normal variant and bales with hop's humidity 13% and higher represented a wet variant. The bales were stored on the first floor of the drying machine house at the grower. The range of storage temperature was from 7 to 40 °C. All square bales were the same conditions (Fig. 1).

The humidity of hops was measured at eight hour intervals. Measurement was done by WILE 25 digital moisture meter made by the FARMCOMP company. The range of this device is from 9 to 22%. There was installed the rod probe W-251 of length 45cm made by the FARMCOMP company too. The device WILE 25 with probe W-251 during measurement is on the Fig. 2. There was no data logging function. The measured data was recorded manually. The humidity was measured two times for each bale. There were measurements at the top and at the bottom of the bale. The final humidity was an average value of these two measurements. The measurements were carried out three times per day at 8 hours intervals for 10 days. There was measurements each day at 8:00, 16:00 and 00:00 h.

Figure 1. Baled hops (Square bales).

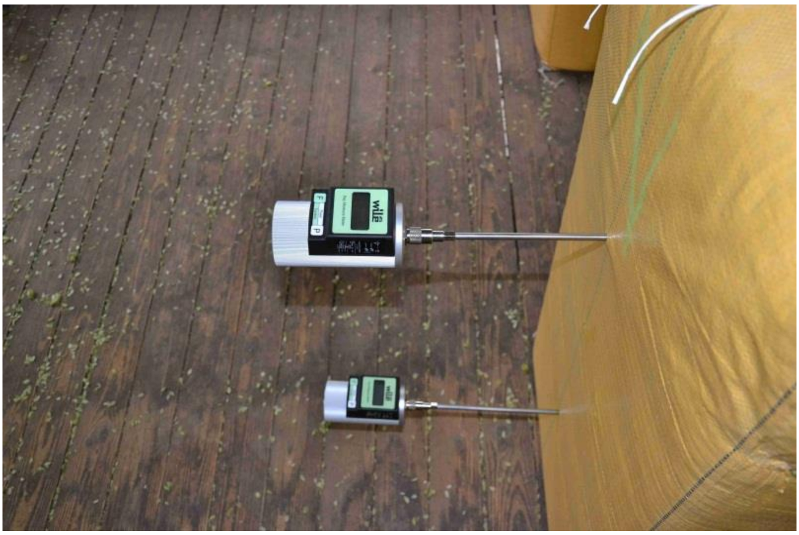

Figure 2. The hops humidity measuring in bales.

There were collected samples of hops for laboratory analysis from each bale. Every sample was tested for content of α-bitter acid by conductometry in accordance with ČSN 432520-15and for quantity of damaged hop cones in accordance with ČSN 46 2520-6. The results were processed and statistically analysed by program Statistica version 9th.

RESULTS AND DISCUSSION

The three bales representing the dry variant had humidity 9.2%, 9.4% and 9.5%. The bales representing the normal variant had humidity 11.3%, 11.3% and 11.6%. The bales representing the wet variant had humidity 13.1%, 13.3% and 16.2%. The last value of the wet variant is higher than we expected, but there was no negative impact for the next measurement. All bales of dry and normal variants do not exceed the limit for the standard quality of hops. The wet variant exceeded the limits and falls into the nonstandard quality hops (Krofta, 2008). Trend of the average daily values of the humidity of all variants can be seen in Fig. 3. At the beginning, there were significant differences between variants. But these differences between variants decreased in time.

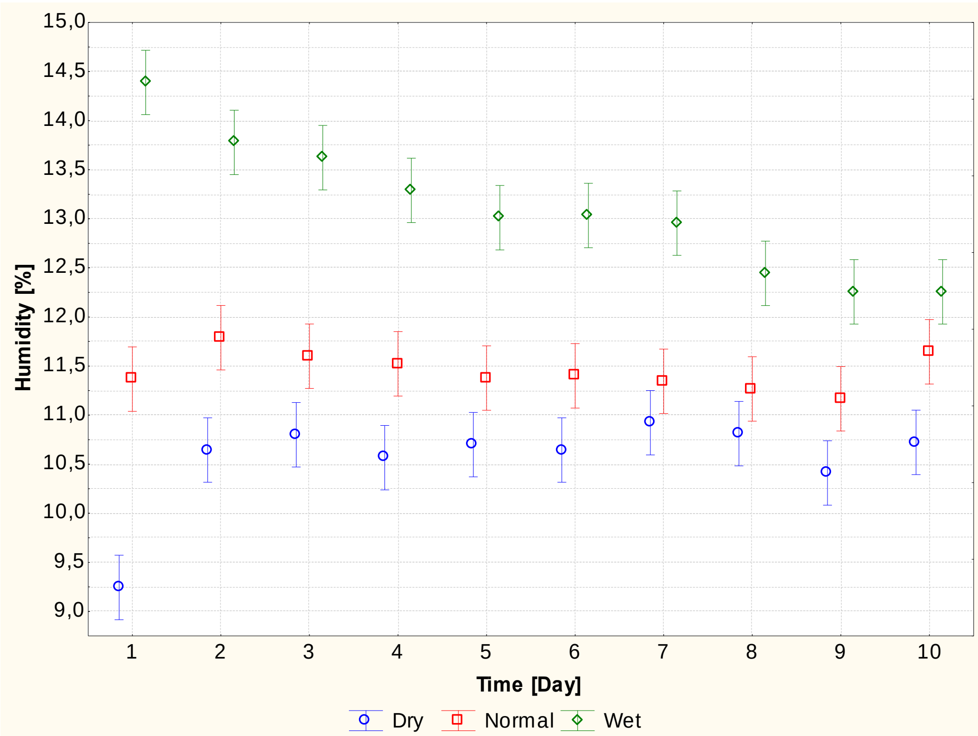

Figure 3. Graphical represention of average values of hops humidity.

As we can see on Fig. 3, there are no significant differences between the dry and normal variant. In the case of normal and wet variant happens the same situation at the last day of the measurement. The Fig. 4 shows low increasing of humidity at dry variant and significant decreasing at wet variant. Normal variant. cured for 11–13% of water had a slight decline, but it was negligible. The average rate of decrease of the wet variant humidity was 0.07% per eight hours. The most significant decrease (1%) was during the 7th day, but next day the humidity increased about 0.87%. At the wet variant, there was no humidity increasing and damping as we expected because of humidity 16.2%, and it is more then says (Krofta, 2008). Average rate of decrease of the normal variant was 0.01% per eight hours. The most significant decrease (0.47%)

and increase (0.83%) were during 9th day. At the dry variant, there was a big increase from 9.2 to 10.7% during the first two days. The most significant decrease (1.1%) and increase (1.53%) were during the 9th day.

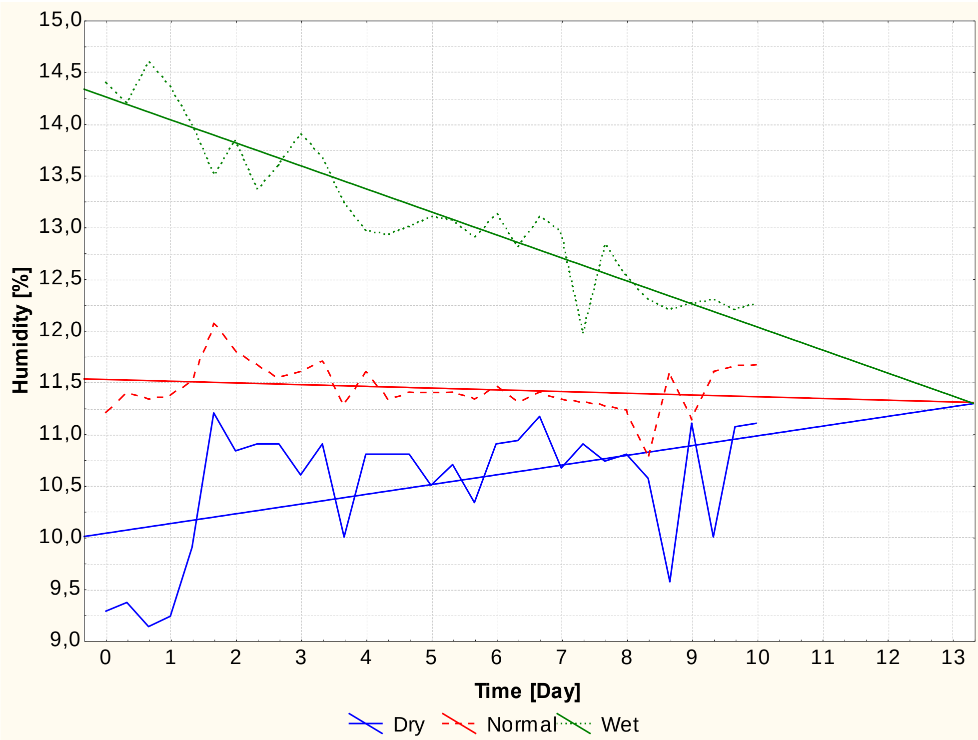

Figure 4. Trend of humidity during storage.

The Fig. 4 shows the trend of humidity of all variants. We can see that the humidity of the wet and dry variant tends to the values of normal variant. The values of the humidity of all variants were between 11.2 to 12.2% last days. This is a difference of 1.1%. At the beginning it was from 9.2 to 14.4% and this is a difference of 5.2%. The range of humidity of all variants was 4.7 times lower after 10 days. Unfortunately, the measurement did not continue. The estimate of the development of the humidity by trend extension is on the graph. Then we find out, that all three variant stabilised themselves at value 11.3% after 14 days of storage. This estimation is only theoretical.

The average values of quantity of damaged hop cones and content of α –bitter acid are shown in Fig. 6. The differences of damaged hop cones between variants are significant. The most of damaged hop cones 28.2% was at the dry variant. The samples of the dry variant had 39.8%, 21.3% and 24.33%. The normal variant had a quantity of damaged hop cones about 43% lower. This result corresponding with the claim of (Krofta, 2008), which tells, that due to low humidity of packaged hops, hop cones become fragile and they are crumbled more during mechanical processing . At the wet variant, there was the quantity of damaged hop cones 16.6%. It is for about 34% more than normal variant.

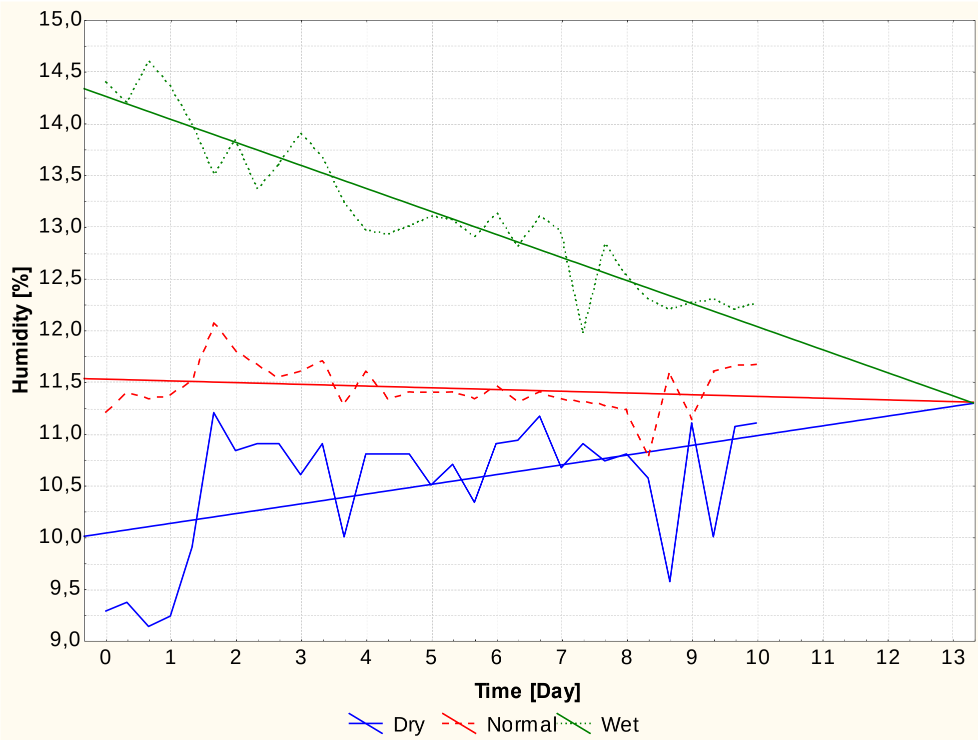

Figure 5. Graphical representation of α - bitter acid content and damage of hop cones.

The laboratory results show, that differences of α - bitter acid contents between variants are not too high. The values of dry and normal variants are almost the same. The dry variant had 3.76 and normal 3.93% of α – bitter acid. The wet variant has a content of water a little higher (4.9%). After evaluation of regression analyses there was not found a significant dependence of hop cone damage on humidity. On the contrary, there is a significant proportional dependence of α – bitter acid's content on the humidity. This dependence is described by regression function of 69.7%. Calculated significance value is less than significance level α = 0.05**,** the correlation coefficient is statistically significant in this case. Graphic representation of the correlation field of α – bitter acid's content and humidity is shown in Fig. 6. Next, the dependence of humidity on the air temperature and moisture was not proven. This corresponds with results of (Vent, 2012), which says that temperature and humidity of stored hops is independent of outside air temperature, but depends on the time of storage.

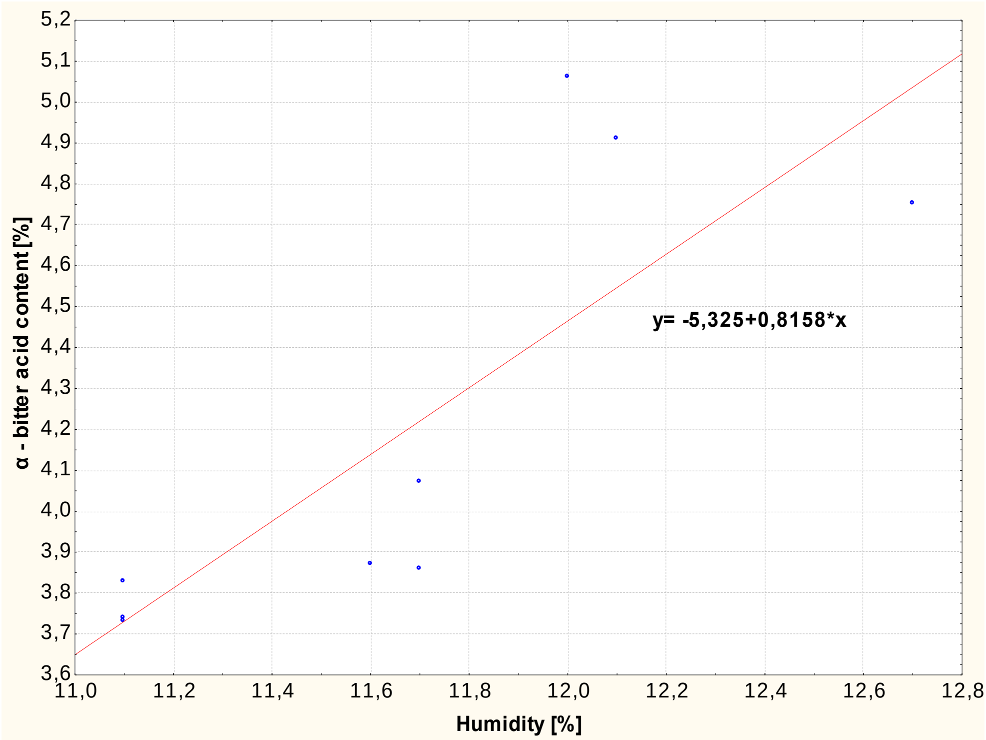

Figure 6. Graphical representation of correlation field of α - bitter acid content and humidity.

CONCLUSION

The measured and calculated results show, that the dried and cured hops containing 16.2% of water, do not increase its humidity and are not prone to damping. On the contrary, humidity of this sample decreases by about 4.5%. The humidity of the dry variant increases itself by about 1.5% during 10 days. The results show, that the best is the normal variant in this case. There were no significant changes of humidity during 10 days of storage at the grower. The content of water of this variant was from 11.3 to 11.6% before pressing. In terms of damage of hop cones the normal variant is the best too. There was the lowest quantity of damaged hop cone. It was 12.3% in this case and it is about 43% less than the dry variant and about 26% less than the wet variant. The content of α - bitter acid was similar for all variants. In this case was proven proportional dependence of the- bitter acid content on humidity. All samples of hops fulfill the requirements of the extra class quality for Saaz hops. The highest average content of α - bitter acid 4.9% had wet variant.

This paper was written with the contribution of MZe CR as a part of research project NAZV

QI101B071 and was supported by Internal Grant Agency, No. 31160/1312/3113.

REFERENCES

CNS 46 2520 'Testing of hop'. Czech Standards Institute, Prague, 1994. (in Czech).

CHMELAŘSTVÍ družstvo Žatec: Hop machinery. Square bale press. Available at: http://chmelarstvi-zavodmechanizace.cz/EN/hranolovy-lis.html.Accessed 2012.

Krofta, K. Methodology of evaluation of hop, Hop Research Institute CO., Ltd., 2008.

Rybáček, V. et al. Hop growing. 1st ed. Prague: SAP, 1980. 422 s. (in Czech).

Vent, L. et al. *Chmelařství: Organizace a technologie výroby*. 1. Praha : SZN, 1963. 409 s. (in Czech).

Vent, L. 2012. Changes of temperature and humidity parameters of picked hop during storage. Municipal machines, n.5, p. 332–336. (in Czech).