HOP PROCESSING SYSTEM INNOVATION WITH FINAL PRODUCT QUALITY INCREASING

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Abstract. The paper presents results concerning elimination of impurity in the final product and comments on how innovation of technology for hop growing and processing systems leads to long term maintenance of final product quality. The experiments were conducted with a suspension of hop and polluting admixtures. The results are to be used for further technological improvement guaranteeing purity of hop granules and so increasing the competitive advantage on the world market.

Keywords: hop, granule, impurity, growing, processing.

Introduction

General requirements on the quality of final agricultural products are ever increasing. The tradition and quality of Zatecky chmel (Saaz hops) forces both the growers and the processing industry to process it in high quality, according to the demands of the world market.

The way of hop packaging and its final treatment have changed significantly in recent years. Currently, the bulk of the hops are being supplied to consumers as hop granules, which have to be purified of all unwanted admixtures.

Materials and methods

All unwanted admixtures presented during hop processing can be divided into two categories:

- admixtures originating during the growing process and subsequent processing;
- admixtures originating from indiscipline of workers participating at hop processing.

These admixtures can be already separated during processing on combing lines by the growers.

To determine suitable places and an appropriate way of eliminating unwanted admixtures on a technological line for hop processing, it was necessary to measure the physical characteristics of hop cones. The samples were collected with respect to possible elimination of unwanted admixtures at various stages of processing. The samples were collected:

- after hop cones get out of stationery hop picker;
- after the hop dryer (simulation by drying in the laboratory under the same conditions as in a dryer);
- after the processing line dryer.

Results and discussion

1. Physical characteristics of hop cones after the stationery hop picker and dryer

To determine the physical characteristic random samples of varieties Zatecky polorany cervenak (ZPC), Premiant, Agnus a Sladek. Out of each sample, 100 pieces of hop cones were randomly chosen to be measured, weighed and their average values were determined. The measure values of the Agnus and Sladek varieties are shown on Fig. 1, 2 and 3. Other 100 to 150 hop cones were taken out of each sample for further laboratory experiments.

The taken samples were dried for about 24 hours at the temperature of 60 °C, which corresponds to the average temperature in belt dryers. The output humidity of the hops was approximately 6.5 %. After drying the samples were stored on a laboratory table to moisten in a natural way. The moisture increased to approximately 11.5 %, corresponding to the subsequent airflow in the dryers. This sample was used for further experiments. To determine the input moisture before drying, the samples were dried at the temperature of 105 °C.

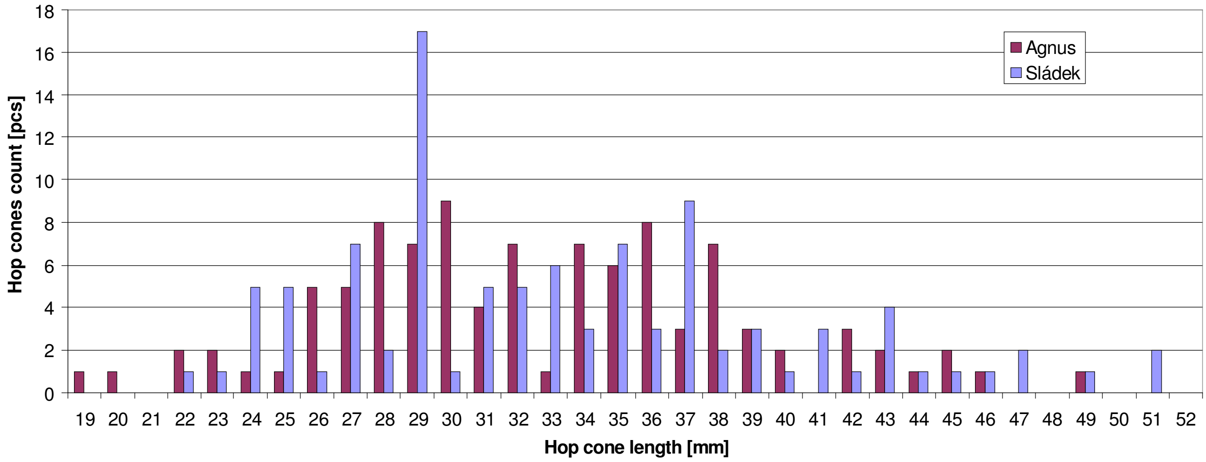

Fig. 1. **Hop cones count versus their length for Agnus and Sladek varieties**

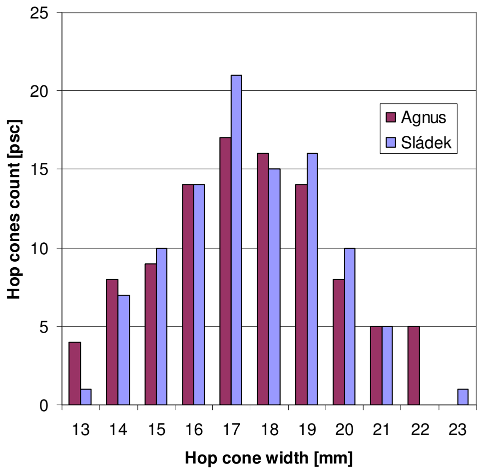

Fig. 2. **Hop cones count versus their width for Agnus and Sladek varieties**

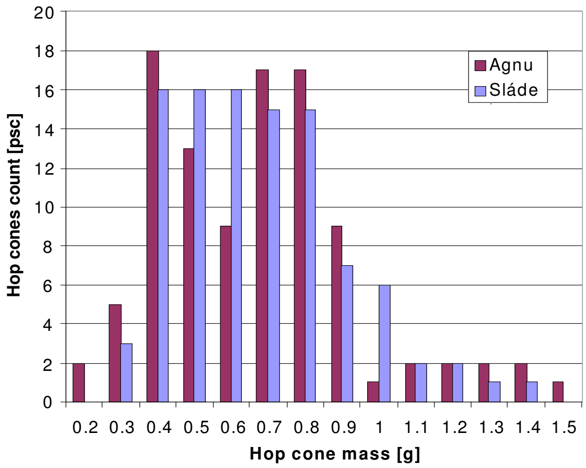

Fig. 3. **Hop cones count versus their mass for Agnus and Sladek varieties**

2. Physical characteristics of crushed hop cones after the processing line dryer

To make hop powder and its subsequent granulation it was necessary to dry the hops getting out of the processing line to dampness of 6-7 %. The sample for determining its physical characteristics was taken after the drying. The hops are roughly crushed by the air transport and homogenizer. This means that the hop cones bracts are separated from the strigs.

During determining the physical characteristics, the randomly chosen sample of crushed hops was loosely poured into a 1 dm^3 graduated vessel. For this volume mass of 43 g was determined and specific mass (density) 43 kg m^{-3} counted.

Furthermore, there were two samples of 50 g taken and gradually put into the receiving hopper of a vertical air-flow classifier. In the classifier the samples were separated into individual fractions depending on the air-flow velocity. The results are shown in Fig. 4.

The sample No.2 shows a slightly different fractional content. The reason of this is probably hop flour, which stuck upon the vibratory loader of the apparatus and partially clogged the fabric filter. Other experiments were shelved.

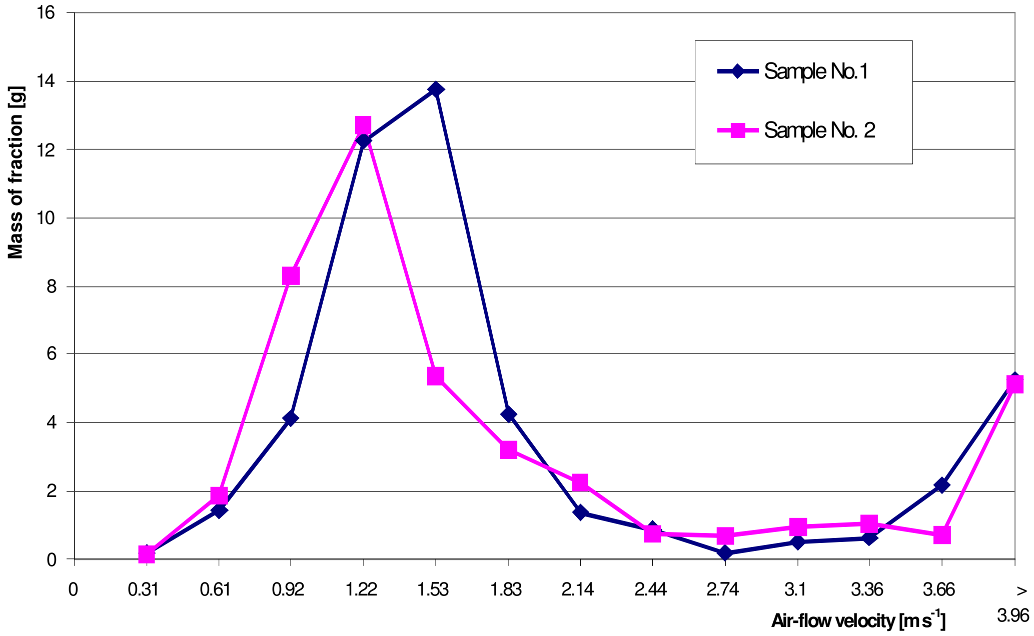

Fig. 4. **Graph of sample fractional division versus air-flow velocity**

3. Critical speed determination

To find out about the behaviour of hop cones, crushed hops and unwanted admixtures in air-flow, a laboratory apparatus was designed and made (Fig.5). The apparatus consists of a radial ventilator (2) run by a three-phase asynchronous motor (1), air pipes (3) and an air chamber (4), the upper part of which is made of glass. To attain a steady flow there were grilles (5) put into the lower part of the chamber. The air-flow velocity was modified with the frequency of rotation of the ventilator by a frequency changer TECO 7300 CV.

Steady flow in the air chamber was confirmed by an anemometr TECHNOVENT 4000.

To measure the critical air-flow velocity the following were gradually placed into the air chamber with the ventilator switched off:

- green hop cones (not dried) of moisture content approximately 75 %;
- hop cones dried to moisture approximately 12 %;
- free strings with or without a nod;
- crushed hops.

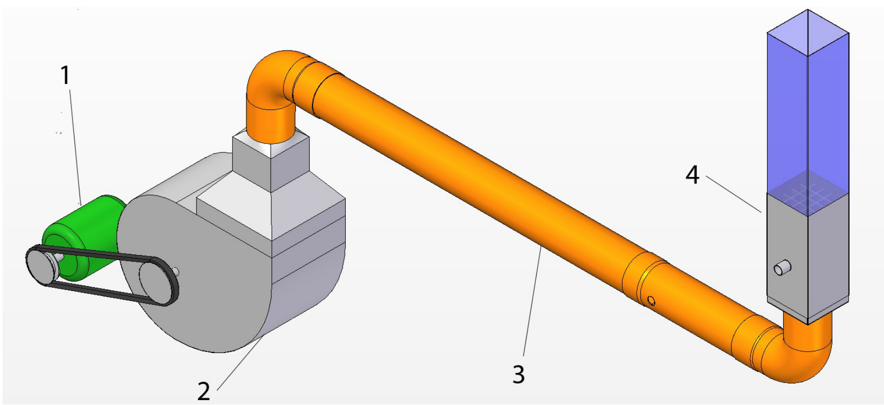

Fig. 5. **Diagram of the apparatus used to determine critical speeds in air-flow**

Having determined critical speeds of all materials, experiments with mixtures were conducted and the possible ways of separation of admixtures determined. The admixtures were constantly represented by free strings, which had been a part of the hop trellis and were taken during the hop harvest. The free strings were both with and without a nod, created by tying of the hop trellis.

The mixtures contained:

- mixture of green hop cones and strings;
- mixture of dry hop cones and strings;
- mixture of crushed hops and strings.

The measuring of critical speeds of mixtures of hop cones and string as well as of crushed hops and strings was video recorded; pictures depicting the mixture behaviour in the air flow were saved. Fig 6. shows the mixture of dry hops and strings when floating. From the picture it is clearly impossible to separate the hop cones and strings, due to their close critical speeds. Measuring with green hop cones and strings mixture brought the same results.

Totally different results were obtained when measuring the mixture of crushed hops and strings. Quite good separation of crushed hops from the strings occurred, due to significantly different critical speeds (Fig7). This was further confirmed by isolated measuring of the crushed hops fraction and the string fraction.

Fig. 6. **Measuring of dry hop cones and strings mixture**

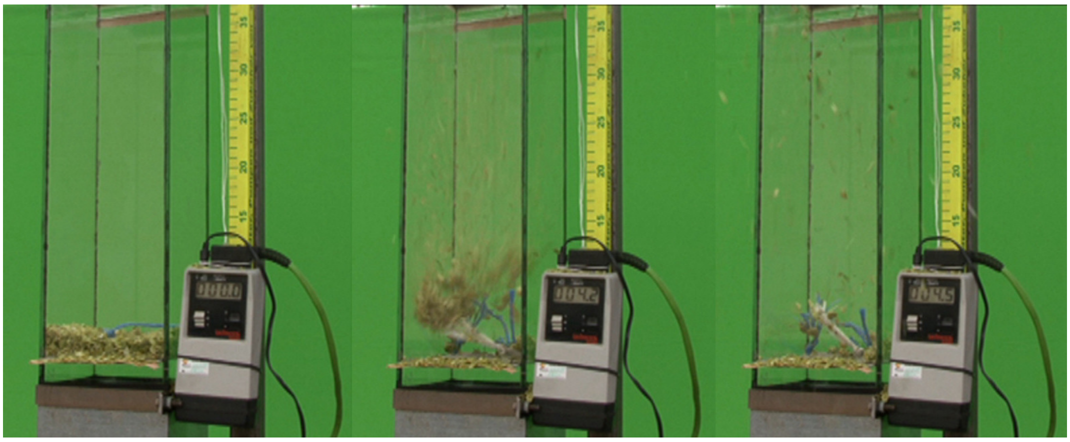

Fig. 7. **Behaviour of crushed hops and strings mixture in air-flow**

As can be seen in the picture, crushed hops start to separate from the strings at the air-flow velocity 4.2 m.s^{-1} and at 4.5 m.s^{-1} full separation follows.

Conclusion

1. The results of the measuring show, that separating green or dry hop cones from the admixtures in the air stream cannot be done due to close critical speeds of both parts of the mixture.
2. On the other hand, it is possible to separate crushed hops from the admixtures in the air stream. The results of the measurements of individual fractions on the classifier suggest that after the hop bracts are separated, the heavier fractions of the crushed hops stay together. These fractions

contain hop strings and seeds. Should we want to use the heavier fractions of the crushed hops during the processing of hops as well, we would have to separate them using the combination of air-flow and mechanical sifting of the heavier remains.

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