Development of an apparatus for measuring the degassing behavior of coffee with the option to examine the influence of protective gases for aroma preservation

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Summary

PROBAT developed an apparatus with which the degassing quantity and the temporal degassing behavior of ground coffee can be determined. At the same time, the influence of protective gases which are used for the ground coffee transport and storage like CO\textsubscript{2} and N\textsubscript{2} on the degassing behavior can be examined. The pressure build-up during the storage in the bin is the factor for the released gas quantity. It has been examined which effects the roasting time, grinding degree and the surrounding atmosphere in the degassing apparatus have on the degassing behavior.

When using protective gases for aroma preservation, it gets obvious that nitrogen as protective gas provides in comparison to carbon dioxide rather for an accelerated degassing of the coffee. This influence is due to the different gas densities of nitrogen and carbon dioxide and thus to the partial pressure influence. Essential influencing factors for the degassing duration are partial drop of pressure and grinding degree: the finer the grain size adjustment, the quicker the degassing.

As variable roasting profiles for the same coffee sort can lead to different degassing curves it is necessary to examine the particular process and the actual coffee sort to receive more precise data. The influences through process and sort can be determined and represented easily with this developed degassing apparatus.

Introduction

Within the last few years coffee roasters often asked questions about the influence of ground coffee degassing. Up to now, this influence has been regarded from different points of view (1, 2, 3, 4, 5). On the one hand, the quality requirements concerning the ground coffee, especially for the pads and pots production, are important. At the same time, the use of protective gases is discussed in connection with aroma preservation and their influence on degassing time and coffee taste. On the other hand, there are the requests of the producers for shorter pass-through times and minimized costs.

When regarding the questions of the market, it partly became clear that generally transferred data of existing examinations did not represent themselves like this in practice. Thus, based on available literature (6, 7, 8, 9, 10, 11) we thought about developing an apparatus which can easily be operated and provides the option to be used at site in order to learn about the different influences of the process.
Design of the apparatus

Different demands should be kept with the apparatus. The gas quantity should be determined and recorded for a certain period of time. Representative coffee quantities should be used for the check. Certain influencing sizes like e.g. the temperature on the gas pressure should be compensable. A simple operation together with the direct presentation of the results must be given as well as the possibility of using the apparatus not only in a laboratory but also on site (12).

A transportable rack (picture 1) was created in which a static comparison in 6 glass bins is made possible. The cabling of the sensors was integrated in that rack and renders possible the recording of the data via a data logger with Laptop connection for direct recording. After trials with different throughflow and pressure measuring systems a Piezo pressure transmitter with a very high measuring accuracy for pressure acquisition was chosen.

Special screwings and special sealings were also used in order to guarantee a gas-tight execution. Each glass bin is equipped with a thermo-couple for temperature acquisition and a pressure relief possibility. Pressure and temperature courses are directly presented by means of the software “Easy View”. Furthermore there is the possibility of introducing selected scavenging gases like e.g. CO₂ or N₂ as well as connection additional analysis equipment e.g. for oxygen measurement. Trials with different filling quantities were made in order to have the sufficient coffee quantity in relation to the necessary free expansion volume for the different coffees and grinding degrees. It was stated that a filling quantity of 250 g of ground coffee is the optimal size.
The gas volume is determined by means of the following formula which is deposited in the software and can therefore directly be presented as serial data curve.

\[
V_{\text{Abgas}} = \frac{\text{Nml}}{600 \text{ g}} = \left[ \left( \frac{(V_{\text{Behälter}} - V_{\text{Füllung}})}{P_{\text{N}}} \right) \cdot \left( \frac{P_{\text{u}} + P_{\text{i}}}{T_{\text{N}} + T_{\text{i}}} \right) - \left( \frac{(V_{\text{Behälter}} - V_{\text{Füllung}})}{P_{\text{Start}}} \right) \cdot \left( \frac{P_{\text{Start}}}{T_{\text{Start}}} \right) \right] \cdot 500 \frac{\text{g}}{G_{\text{Füllung}}}
\]

- \( V_{\text{Abgas}} \): degassing volume
- \( V_{\text{Behälter}} \): bin volume
- \( P_{\text{u}} \): surrounding pressure
- \( P_{\text{i}} \): pressure inside bin
- \( P_{\text{N}} \): norm pressure
- \( P_{\text{Start}} \): inside pressure when measuring
- \( T_{\text{N}} \): norm temperature
- \( T_{\text{i}} \): temperature inside bin
- \( T_{\text{Start}} \): temperature when measuring
- \( G_{\text{Füllung}} \): filling weight

**Measuring results**

During the first trials the final alignment was compared with measuring details which could be found in literature (1, 7, 11). Clearly comparable results like e.g. for the grinding degree showed themselves. (picture 2).

![Diagram](image-url)

**picture 2: measuring results – grinding degree**

It gets obvious that the finer the grinding degree the lower is the gas volume which is released. The reason for this is that more cells are destroyed during a fine grinding process by which the gas stored in the cells is already released during the grinding process.

a) Comparison treated/untreated green coffees

Measurements of Arabica coffee where untreated green coffees and green coffees treated as per the DCM procedure have shown that the roasting time influence on the ground coffee degassing for treated Decafs does not exist any longer. Furthermore the roasted coffee, a product of treated green coffee, degasses faster at the beginning and in comparison to untreated Arabicas they release a gas volume which is 15 – 20 % lower (picture 3). The reason for this is the cell structure which is changed by the decaffeinating process so that there are more and more open pores and lower cell wall thickness after the treatment and the roasting process (picture 4 a-d).
Another Arabic coffee which was treated as per the Lendrich procedure showed a degassing quantity which is 12% lower but the roasting time influence could not be recognised for the untreated green coffee either (picture 5). There is no difference in the relation between the gas amounts in the comparable period of time at the beginning of the degassing process.
The lower degassing quantity then again can be explained by the modified cell structure as consequence of the pre-treatment (picture 6 a-d).
b) Comparison roasting time and coffee sort

An astonishing result shows the comparison of the two coffee sorts Vietnam Robusta and Brasil Rio Minas. With view to comparable grinding degrees and roasted coffee colours the Arabica with the shorter roasting time has a degassing quantity which is 25% lower compared with the coffee which was roasted longer. With regard to Robusta, the ground coffee with the shorter roasting time has a degassing quantity which is 20% higher than the one with the longer roasting time (picture 7). This shows that the influence of the roasting time has an opposite effect on the released gas quantity of the respective coffee sort.

We also learned about a certain effect with very dark roasted coffees which probably has to do with the “second crack”. The very dark roasted coffee again has a lower degassing volume than the lighter roasted coffee sorts.

These results may be surprising but it is, however, only a further proof why general statements about the degassing behavior of the natural product are difficult. The single coffee sorts with their respective production processes must be studied individually in order to work out optimisations concerning quality and/or production.

Influence of protective gases

In order to check the influence of protective gases on ground coffee, among others, measurements on gas-tight ground coffee silos took place. 420 kg of ground coffee of equal, fresh roasted quality were filled per silo. Ground coffee with normal oxygen atmosphere of the environment was stored in silo No. 1. In order to reach oxygen values under 0.5%, silo No. 2 was scavenged for 15.6 minutes with 3.4 m³ CO₂ and silo No. 3 for 17.3 minutes with 5.8 m³ N₂. After identical storage times samples were taken from each silo and were enclosed in the degassing apparatus in order to determine the remaining degassing quantities.

The coffee with N₂ application released a lower quantity of residual gas volume than the coffee of the other two silo compartments which refers to a higher degassing quantity in the silo (picture 8). This degassing of coffee which tends to be accelerated under the N₂ conditions is due to the gas density, thus to the influence of the partial pressure (picture 9).
Already during the grinding process, the coffee is protected against ageing which takes place due to the influence of air oxygen. Whether CO₂ or N₂ is chosen as protective gas is a question of cost and also depends how the taste of the coffee in the cup is perceived. There are very different opinions in the market concerning the “influence of protective gases on the taste”. It is known that oxygen must be kept away from coffee in order to protect the aroma. Thereby protective gases can be of help. Test in laboratory scale can be done with the degassing apparatus with the target to find out the optimal aroma protection for the respective coffee.

The PROBAT Controx System was optimised on the basis of the existing examination results and the modular construction was adapted to the demands of the market (picture 10). This system offers the possibility of implementing an individual aroma protection.


