Precision for homebrewers: EasyDens

A test report by Oliver Weiss

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Content

What is EasyDens?

With EasyDens, Anton Paar [1] launches a precise meter to measure extract content and density for homebrewers. The integrated measuring technology is based on the digital oscillating U-tube technology usually found in well-equipped breweries or test labs.

Figure 01: EasyDens

To display the measurement results and to set up or calibrate the instrument, EasyDens communicates with an associated app connected via Bluetooth. With this modular concept, EasyDens presents itself with a pocket sized and modern design, capable of measuring samples between 5 °C and 30 °C with automated temperature compensation of the displayed degrees Plato °P [24)].

The most important specifications for EasyDens are presented by Anton Paar as follows (status: 02/2016):

- Measuring range: temperature 5 °C to 30 °C, extract content -10 °P to +40 °P
- Accuracy: temperature 0.2 °C, extract content 0.3 °P [23)]
- Repeatability, s.d. temperature 0.1 °C, extract content 0.2 °P [22)]
- Resolution: temperature 0.1 °C, extract content 0.1 °P 23)
- Sample volume: approx. 2 mL
- Display of the measured results optionally in: specific gravity SG, °Plato °P, density in g/cm^3, density in kg/m^3 [21,24)]

Density measurement, oscillating U-tube method and EasyDens in the midst of it

Density measurement based on the oscillating U-tube method is described and acknowledged in the analytical manuals of MEBAK[5], EBC[6] and ASBC[7]. The fact that modern beer measuring systems are all equipped with an oscillating U-tube as the main component for density and extract measurement indicates that homebrewers are presented with a high-end density meter and can expect several advantages over conventional extract measurement:

- A highly precise and repeatable density measuring instrument for samples taken before, during and after fermentation
- No temperature and density measurement reading errors
- No manual conversion into other units necessary
- Automated temperature compensation for the displayed °P
- Fast and exact measurement results from a small sample volume (2 mL)
- Simple handling, small, minimal cleaning effort, and robust
- Measurement results can be read "on the fly" in different units

General Article Information

The following article takes a closer look at EasyDens in the hobby brewing environment and questions the specifications given by the manufacturer by performing diverse instrument tests. First though, we will preface the methods for carrying out the measurement series and for the article itself:

A list of used reagents are found in appendix A and a list of used instruments are found in appendix B. Definitions are listed in appendix C. References to the appendices A, B and C are given in paranthesis and the according entry number, e.g. [1)]. Source references are written in squared brackets and can be found at the end of the article.

Before measurement, the samples were tempered to 20 °C as well as possible. The reason for this is the manual/visual temperature compensation of the read hydrometer value which must be performed when dealing with deviating sample temperature. This process easily turns into an estimation in borderline cases. Hence, tempering the samples to 20 °C is rather a concession to the hydrometer, especially as the temperature compensation of EasyDens is checked separately within this article.

Aside from parts of the instrument tests, identical samples were always measured 5 times in a row. A single measurement cycle of EasyDens was always arranged as follows: First, 2 to 3 mL of the sample were used and 20 seconds later the measurement results were read. Not performing a statistical evaluation was a conscience decision.

The weighing of reagents and raw materials, such as sugar, hops and yeast, was done in typical '*hobby brewer's fashion*, namely with a kitchen scale[15)]. Where the article refers to 1g/liter dry yeast or similar, the components were weighed with the above mentioned kitchen scale. At first I tried to weigh larger quantities and then achieve the desired concentration by dilution. It can be assumed that the precision leaves something to be desired.

I indicate the measurement results of EasyDens either in the unit name *EasyDens [%mas] (°P)* or in the unit name *EasyDens [%mas]*. In the EasyDens App every reading unit was given in °P. To display all measurement values in °P however, without differentiating between fermented or unfermented, seemed unfortunate to me. °P is the unit for the original extract[24)] and the original extract exclusively refers to an extract concentration which per definition is present before fermentation. The original extract can't be determined in °P through simple density measurement when the yeast is added to the wort, the wort is partially fermented or fermented. Typically, the determined extract values in partially fermented or fermented samples are indicated as apparent extract *AE* 20) in the unit percentage by weight *[GG%]* or in percentage by mass *[%mas]* 18). The name of the column header takes account of that. On requests made to the manufacturer, the coming versions of the app will take these details in account.

Scope of supply, equipment and basic steps in handling EasyDens

Unboxing

EasyDens is supplied with a sample syringe, all the adapters, seals, batteries and hoses required for a first measurement. In addition, you get a protective cover that serves as splash protection and ensures sufficient stability. A flyer with illustrations and information for installation, cleaning, measurement and adjustment is included.

Anton Paar's EasyDens App for Android can be downloaded and installed for free from the Google Play Store. According to the manufacturer, an app for Apple's iPhone is going to be released in March 2016.

A complete instruction manual [8] is available for download in pdf format on the website of Anton Paar. In various appendices of the instruction manual there are additional conversion tables for the density of water [3], a declaration of conformity, a parts list, specifications, Bluetooth regulations, etc.

Installation

Step by step, following the illustrations on the flyer, EasyDens was brought into operation. At the same time the app was installed. After almost 10 minutes the instrument was ready and a first measurement could be performed. The instruction manual in combination with the illustrated flyer leaves nothing to be desired.

Adjustment (checks and adjustments)

An adjustment function is listed in the EasyDens App menu. The process is performed as easily and quickly as a measurement. The instrument that I was provided with was adjusted with delivery. Should there be a *water adjustment* necessary, the instrument needs to be filled with distilled water. Then you simply select “*Adjustment*” in the app. The rest is done by the instrument itself.

The measurement

The measurement is quite simple. The sample is drawn into the syringe and subsequently inserted into the instrument. The required sample amount (min. 2 mL) is injected into the measuring cell. After a few seconds, the result is obtained and read in the afore mentioned parameters via the app. It should be mentioned here that only the unit °*Plato °P* is displayed as a temperature-compensated value. The display of all the other parameters depends on the actual sample temperature.

How to prepare a sample for the measurement is described in the instruction manual. Nevertheless, at this point some important information concerning sample preparation:

An oscillating U-tube is a high-precision instrument that measures all particles and substances which are more or less dissolved in a sample. The density measurement by oscillating U-tube is always an overall measurement of all components of a sample. For this reason, all sample measurements performed with an oscillating U-tube must be free of particles, as clear as possible and degassed. Anton Paar also points this out in the EasyDens instruction manual. The article will take a close look at this measurement requirement and the sample preparation.

Cleaning and maintenance

Cleaning and maintenance does not involve too much effort. Basically, it is sufficient to rinse with lukewarm, demineralized water [2)] after the measurement and pressing air through the measuring cell (from the syringe). A more involved cleaning should be done in greater intervals. Regardless, the manufacturers recommended procedures should be followed.

Test environment: EasyDens and its antagonists

EasyDens will be compared to different glass hydrometers of various quality:

- Homebrewer hydrometer, 0 to 20 %mas [19,9)]
- Calibratable hydrometer, 0 to 7 %mas [19,10)]
- Calibratable hydrometer, 7 to 14 %mas [19,11)]

In cases where unexplainable deviations between hydrometer and EasyDens appeared, a factory-calibrated high-precision oscillating U-tube meter of the type *DMA 4500 M*[13)] from Anton Paar was available. This density meter measures density reliably with a precision of 0.00005 [g/cm^3].

Why was there no Brix refractometer included in the testing environment?

There was no calibratable instrument available and a comparison would have only related to exactly one model. The number of *refractometer products* with diverse measuring range, scaling, precision and model (analog, digital, with ATC, without ATC ...) makes it hard to get an overview. Furthermore, a read Brix value in unfermented wort needs to be converted by a factor into °P. A calculated Brix value in fermented wort needs a whole formula to be converted. There is no other way to make a comparison with the “*normally*” calculated density value (apparent extract)[18,20,21]. Since the whole community doesn’t completely agree on which factor or formula to use under which circumstances (Standard, Terrill[9]) the Brix refractometer was not considered for a sincere comparison.

The test cases at a glance

- Distilled water. Calibration check
- Temperature compensation check
- Instrument comparison
- Sugar solutions
- Turbid and filtered wort samples, cooked or uncooked, hopped and unhopped, with and without hot break, with and without yeast
- Turbid and filtered "green beer" samples during fermentation, degassed and not degassed
- Turbid and filtered "finished beer", degassed and not degassed
- Turbid and filtered "finished beer", degassed. Turbidity due to protein, starch, yeast

Figure 02: The kitchen becomes a brewery lab

Check measurement: Ensuring the instrument is ready to measure

In chapter 11 of the instruction manual [8] the check measurement is described with deionized water [2)] in °Plato °P as follows:

*"If the measuring value is in the range **±0.3 °Plato**, your EasyDens is ready for measurements. If the measuring value is **below –0.3 °Plato** or **over +0.3 °Plato**, perform a water adjustment."*

Table 01. Check measurement: EasyDens with laboratory quality[1)] bi-distilled water

Measurement	Reading [°C]	EasyDens [%MAS] (°P)
1	20.1	-0.1
2	20	-0.1
3	20.1	0
4	20.1	0
5	20.1	-0.1

The instrument doesn’t need a water adjustment. All 5 measurements of one identical sample showed measurement results within the tolerance (+/- 0.3 °P) I performed this check measurement before every test. The result was always the same or similar. A water adjustment wasn’t necessary throughout the whole experimental period.

Check measurement: Checking the temperature compensation

According to Anton Paar, measurements in the unit °Plato °P are automatically temperature compensated in the temperature range between +5 °C and +30 °C. This means that single measurements of identical samples done with different temperatures (from +5 °C to +30 °C) will always lead to the true Plato value, measured at 20 °C.

Table 02. Check measurement: EasyDens with bi-distilled water and verification of the temperature compensation at approx. 5 °C and approx. 30 °C

Reading [°C]	EasyDens [%MAS] (°P)
20.2	0
30	0.1
5.2	0

EasyDens displays almost identical measurement results in the unit °P in the temperature range between + 5 °C and +30 °C. The temperature change of the sample has no influence on the measurement results. The temperature compensation works.

Comment:

The sample volume of 2 mL is very low. The temperature of a sample within the measuring cell changes constantly and in big steps - you can literally watch it. In that context it’s interesting that the displayed measurement result in °P stays untouched - it stays constant. This behavior of EasyDens was observable for the displayed °P in the whole experimental period. For me it’s clear that the temperature compensation for the displayed °P and for the specified temperature range works perfectly fine.

The two next test cases take a closer look at the instruments used [9,10,11,12,13)]. The goal is to check the quality of the individual instruments and provide information as to the comparability of the measurement results.

The instruments in comparison: distilled water

Table 03. The instruments in comparison: Bi-distilled water at 20 °C

Instrument	Reading [°C]	Reading [%MAS] (°P)
Calibratable hydrometer, 7 to 14 [%mas]	20	---
Calibratable hydrometer, 0 to 7 [%mas]	20	0
Homebrewer hydrometer, 0 to 20 [%mas]	---	~ 0.2 | 0.3
EasyDens	20	0
Control value DMA 4500 M	20	0

All instruments, with the homebrewer hydrometer the only exception, displayed correct results with distilled water. To check the measurement results the *DMA 4500 M* was put into operation. The calibratable hydrometer 7 to 14 %mas [11)] disqualified for this test.

The instruments in comparison: sugar solution

Table 04. The instruments in comparison: Sugar solution 7 [% mas] (°P). In homebrewer manner the weight percent sugar solution was produced in the quality "kitchen scale" with commercial distilled water and household sugar.

Instrument	Reading [°C]	Reading [%MAS] (°P)
Calibratable hydrometer, 7 to 14 [%mas]	20	7
Calibratable hydrometer, 0 to 7 [%mas]	20	7
Homebrewer hydrometer, 0 to 20 [%mas]	---	~ 6.5
EasyDens	20.1	7
Control value DMA 4500 M	20	7.04

The weight percent solution turned out well, despite the use of a kitchen scale. The two calibratable hydrometers and EasyDens show identical and true results for clear sugar solutions. The *DMA 4500 M* was introduced for final control and confirms the assumption. The hobby brewer hydrometer is unsuitable for further comparisons due to its rough scaling and its insufficient precision. It will not be considered further.

In the following test series EasyDens has to compete with the two calibratable hydrometers used in the homebrewer environment.

First, the unfermented wort samples from different production steps are analyzed. Such samples are usually more or less turbid, contain no alcohol and no carbon dioxide (CO_2). I once again want to point out that Anton Paar explicitly states that samples need to be clear, free from particles and degassed. That's why identical samples are first measured turbid and then clear[5]. This comparison should show which influence a possible turbidity has on EasyDens and hydrometer measurements.

In order to avoid a mix-up of the results, the result tables were given sample labels. An identical sample label indicates that only the sample preparation has changed, not the sample itself.
The two series of tests in *Tab.05* and *Tab.06* look at a random, uncooked and unhopped wort sample comparing turbid/clear.

Wort uncooked and unhopped comparing turbid/clear

Table 05. Wort sample turbid, uncooked and unhopped. Sample label #1.

Measurement	EasyDens [%MAS] (°P)	Hydrometer [%MAS] (°P)
1	9.7	9.6
2	9.7	9.6
3	9.6	9.6
4	9.7	9.6
5	9.7	9.6

Table 06. Wort sample filtered, uncooked and unhopped. Sample label #1

Measurement	EasyDens [%MAS] (°P)	Hydrometer [%MAS] (°P)
1	9.7	9.6
2	9.6	9.6
3	9.7	9.6
4	9.6	9.6
5	9.6	9.6

Comparing turbid/clear shows no notable changes of results for EasyDens. The turbidity of an uncooked and unhopped wort seems to have no influence on the measurement with EasyDens. The values for precision and repeatability stated in the specifications of EasyDens are met without any problem.

Wort cooked and hopped comparing turbid/clear

The two series of tests in *Table 07* and *Table 08* look at a random, cooked and hopped wort sample comparing turbid/clear.

Table 07. Wort sample turbid, with 1g/L hops[8] cooked (hot break and spent hops were not removed). Sample label #2

Measurement	EasyDens [%MAS] (°P)	Hydrometer [%MAS] (°P)
1	10.9	10.8
2	10.8	10.8
3	10.8	10.8
4	10.8	10.8
5	10.8	10.8

Table 08. Wort sample filtered with 1g/L hops [8] cooked (hot break and spent hops were removed). Sample label #2

Measurement	EasyDens [%MAS] (°P)	Hydrometer [%MAS] (°P)
1	10.8	10.9
2	10.8	10.9
3	10.9	10.9
4	10.8	10.9
5	10.9	10.9

Comparing turbid/clear shows no notable changes of results for EasyDens.

The turbidity of a cooked and hopped wort seems to have no influence on the measurement with EasyDens. The values for precision and repeatability stated in the specifications of EasyDens are met without any problem.

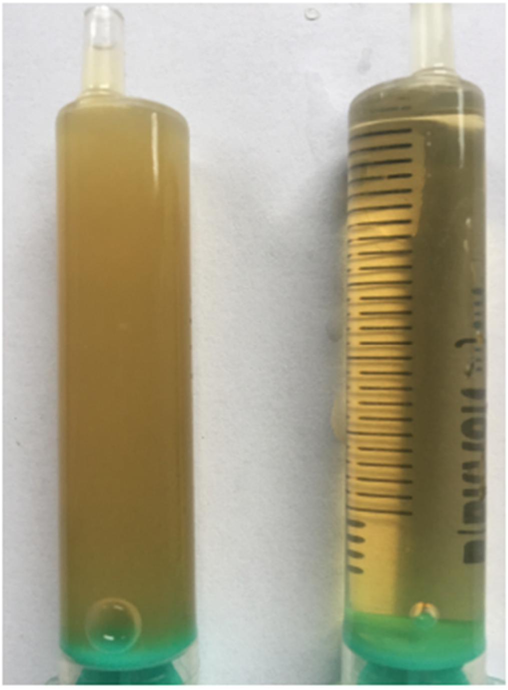

Figure 03: On the left, the turbid wort sample from the measurement series Table 07, on the right the filtered wort sample from the measurement series Table 08. Sample label #2

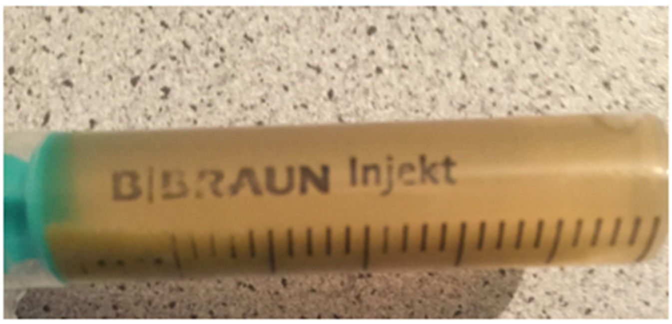

Figure 04: The turbid wort sample from the measurement series Tab. 07 after 30 minutes of sedimentation time. Sample label #2.

The quantity of trub which is clearly recognizable as sediment has no influence on the measurement results. Really amazing.

Pitched wort unfermented and with turbidity due to yeast

Table 09 continues the test series for samples with label #2. 2 g/L of dry yeast is added to the measured clear sample in Table 08 (clear pitched wort). The yeast concentration equals 2 to 4 times the dry yeast amount which is usually recommended for dry yeast by manufacturers.

Table 09. Turbid pitched wort, unfermented, with 2g/L dry yeast[7)]. The turbidity is caused by the yeast pitching. Hot break, parts of the cold break and spent hops were removed before pitching the yeast. Sample label #2

Measurement	EasyDens [%MAS] (°P)	Hydrometer [%MAS] (°P)
1	11	10.9
2	11	10.9
3	11	10.9
4	11.1	10.9
5	11	10.9

Compared to the hydrometer, EasyDens shows a slight increase of the measurement results compared to the clear sample (Table 08) due to massive yeast turbidity (Table 09). This is not the case with the hydrometer. The yeast turbidity of a previously filtered pitched wort seems to have a certain influence on the measurement with EasyDens. The values for precision and repeatability stated in the specifications of EasyDens are met without any problem.

Main fermentation sample turbid/clear and non-degassed/degassed

In Table 10 a measurement is displayed that shouldn't be done in the first place, according to Anton Paar. The sample was removed during the main fermentation. It is very turbid and not degassed.

Table 10. Main fermentation sample turbid, unfiltered and not degassed. CO_2 content approx. 1.6 g/l. Sample label #3

Measurement	EasyDens [%MAS]	Hydrometer [%MAS]
1	8.3	8.4 to 8.7
2	8.4	8.4 to 8.7
3	8.3	8.4 to 8.7
4	8.4	8.4 to 8.7
5	8.3	8.4 to 8.7

The readings from the hydrometer are estimations. The non-degassed sample is giving the hydrometer a hard time. The sample degasses in the graduated cylinder and the ascending CO_2 makes the hydrometer rise and adheres to the hydrometer body. The foam does the rest. Additionally, you need to read the temperature and you might even need to correct the displayed result. I think the problem is known. The reading from the hydrometer is only an estimated result.
The sample in the 5 mL syringe of EasyDens also always changes its appearance. When the syringe is attached to the instrument it is clear to see how the CO_2 gathers in the upper part of the syringe. If only a part of the sample is used for EasyDens the

CO_2 which is accumulated in the upper part of the oscillating U-tube also forms in the measurement cell. These little amounts of CO_2 in the upper part of the oscillating U-tube seem to have hardly any effect on the repeatability of the measurements. The measurement results in the complete test series are quite constant despite the small CO_2 bubbles in the upper part of the oscillating U-tube.
The filtration and degassing of the main fermentation sample from Tab.10 (sample label #3) should show the correct measurement results.

Table 11. Main fermentation sample filtered and degassed. Sample label #3

Measurement	EasyDens [%MAS]	Hydrometer [%MAS]
1	8.2	8.1
2	8.1	8.1
3	8.1	8.1
4	8.2	8.1
5	8.1	8.1

Figure 05: Main fermentation sample in Erlenmeyer flask. Sample label #3

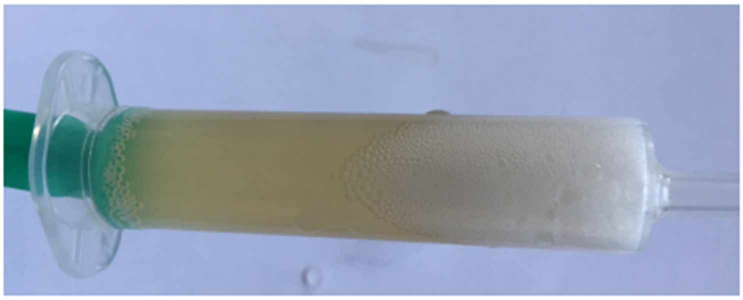

Figure 06: Main fermentation sample unfiltered and non-degassed in the syringe. *Sample label #3*

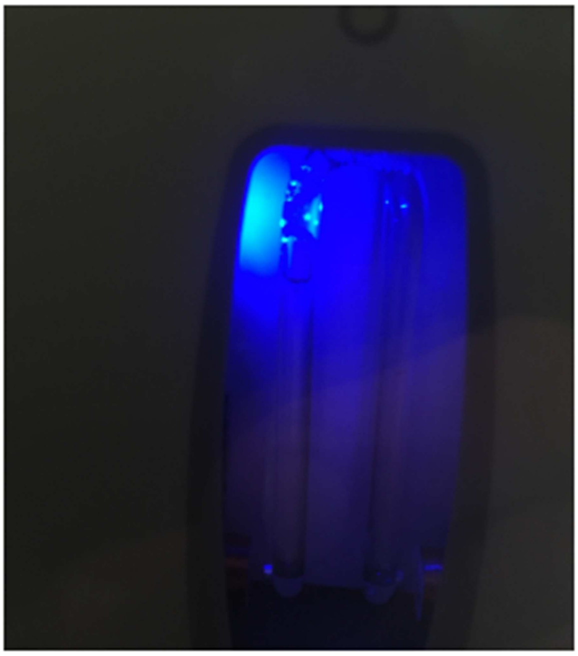

Figure 07: Main fermentation sample unfiltered and non-degassed in the measurement chamber. The released CO_2 is clear to see in the upper part of the oscillating U-tube. Sample label #3

Unbelievable. Also these or similar samples could be measured with high repeatability and precision.

But note: That's how it's NOT supposed to look. If you have such a CO_2 release in your oscillating U-tube you need to fill in an extra amount of 2 mL of the sample. If necessary degas the sample. Then you can measure again. See section "Tips for degassing of samples - syringe degassing" further down in the article.
For the filtered and degassed main fermentation sample with the sample label # 3 the hydrometer and EasyDens display coherent and consistent measurement results. Although the main fermentation sample was not degassed and not filtered the measurement results of EasyDens were within the tolerance for precision and repeatability as stated by the manufacturer.

Measurement result summary for sugar solution, wort and "green beer"

The analysis so far has shown that EasyDens is able to handle sugar solutions, clear and turbid wort (preferably turbidity due to protein or hops), clear and turbid pitched wort (preferably turbidity due to yeast) and weakly carbonized (<= 1.7 g/L CO_2) "green beer". A strong yeast turbidity of the sample has a stronger influence than a strong protein or hops turbidity. The values for precision and repeatability stated in the specifications of EasyDens are met for all named samples.

The effect of different turbidities on measured results

After pitching, the samples are more or less turbid and contain more or less CO_2. Removing the CO_2 from a small sample amount is done really fast and I will give some tips for degassing at the end of this article. It's a bit more tricky when the sample needs to be filtered. You need folded filters (coffee filters), a suitable hopper and if necessary diatomaceous earth to make sure that the folded filter won't "close down" after just a few milliliters. Such a filtered sample is the best for a measurement with an oscillating U-tube because the sample is clear and degassed. On the other hand, this is additional effort which you may want to avoid. The following tests show, to what extent such filtration of a turbid sample can be avoided.

The upstream tests have shown that strong yeast turbidity has an impact on the measurement while turbid wort, which doesn't contain any yeast, has no influence. Besides the turbidity caused by a large amount of rough particles there are said to be three further types of turbidity:

- Protein turbidity
- Starch turbidity
- Yeast turbidity

These different turbidity types are tested separately and as well as possible. I chose two finished products of which I know the production process. One of those finished products is a pale wheat beer with a turbidity preferably caused by protein rather than yeast. The other finished beer is a turbid cellar beer with a turbidity preferably caused by starch rather than yeast. The finished beer samples were degassed and then underwent three different measurements.

- Unfiltered (at 20 °C, the way they come out of the bottle)
- Filtered
- First filtered and then adding 4 g/L dry yeast

As a side note, when measuring an amount of turbid samples it is quite complex to keep the individual samples homogeneous. Turbidity is sensitive to time and temperature, therefore its appearance is constantly changing. This does not only apply for the sample but also for the measurement cell. Therefore, it is possible that turbidity characteristics of a sample change during the measurement. Consequently, the measurement results and the comparative values could vary uncontrollably.

Influence of mainly starch induced turbidity

Table 12. Fermented finished beer from the bottle. "Cellar beer turbid". Turbidity mainly caused by starch. Degassed and unfiltered. Sample label #4

Measurement	EasyDens [%MAS]	Hydrometer [%MAS]
1	2.6	2.6
2	2.6	2.6
3	2.6	2.6
4	2.6	2.6
5	2.6	2.6

Table 13. Fermented finished beer from the bottle. “Cellar beer turbid”. Turbidity mainly caused by starch. Degassed and filtered. Sample label #4

Measurement	EasyDens [%MAS]	Hydrometer [%MAS]
1	2.6	2.6
2	2.6	2.6
3	2.5	2.6
4	2.6	2.6
5	2.6	2.6

EasyDens doesn’t show any difference when measuring with samples that are clear or turbid due to starch. Both samples deliver identical measurement results. The amount of dry yeast is increased 4 to 8 times and added to the filtered sample with starch turbidity (the amount is 4 to 8 times as much as the manufacturer recommends).

Table 14. Fermented finished beer from the bottle. “Cellar beer turbid”. Turbidity mainly caused by starch. First filtered and then adding 4 g/L dry yeast. Sample label #4

Measurement	EasyDens [%MAS]	Hydrometer [%MAS]
1	2.8	2.7
2	2.8	2.7
3	2.8	2.7
4	2.8	2.7
5	2.7	2.7

The massive yeast turbidity in sample #4 shows some effect. EasyDens measures ~ 0.2 %mas more. But also the hydrometer does not stay completely untouched. The values for precision and repeatability stated in the specifications of EasyDens are met anyway.

Influence of mainly protein induced turbidity

Table 15. Fermented finished beer from the bottle. “Wheat beer turbid”. Turbidity mainly caused by protein. Degassed and unfiltered. Sample label #5

Measurement	EasyDens [%MAS]	Hydrometer [%MAS]
1	2.4	2.4
2	2.4	2.4
3	2.4	2.4
4	2.4	2.4
5	2.4	2.4

Table 16. Fermented finished beer from the bottle. "Wheat beer turbid". Turbidity mainly caused by protein. Degassed and filtered. Sample label #5

Measurement	EasyDens [%MAS]	Hydrometer [%MAS]
1	2.4	2.4
2	2.4	2.4
3	2.4	2.4
4	2.4	2.4
5	2.4	2.4

EasyDens doesn't show any difference when measuring with samples that are clear or turbid due to protein. Both samples deliver identical measurement results. The amount of dry yeast is increased by 4 to 8 times and added to the filtered sample with turbidity due to protein (the amount is 4 to 8 times as much as the manufacturer recommends).

Table 17. Fermented finished beer from the bottle. "Wheat beer turbid". Turbidity mainly caused by protein. First filtered and then adding 4 g/L dry yeast. Sample label #5.

Measurement	EasyDens [%MAS]	Hydrometer [%MAS]
1	2.7	2.5
2	2.7	2.5
3	2.8	2.5
4	2.7	2.5
5	2.7	2.5

The massive yeast turbidity in sample #5 shows some effect. EasyDens measures ~ 0.3 %mas more. But also the hydrometer does not stay completely untouched. The values for precision and repeatability stated in the specifications of EasyDens are met anyway.

Summary: Effect of yeast, protein and starch turbidity on the measurement result

Everyday turbidity caused by protein and starch in wort and beer does not influence the density measurement (°P) with EasyDens. Comparable significant turbidity caused by yeast shows an upward tendency, whereby the pitching concentration of dry yeast needs to be 4 to 8 times of the recommended amount. For the sake of completeness it should be mentioned that the precision hydrometer also shows upwards tendencies in that kind of sample environment. The values for precision and repeatability stated in the specifications of EasyDens are met for all named samples.

Degassing samples - yes or no?

In general, yes. But it is not always necessary. A non-degassed sample is not suitable for a reliable density measurement regardless of the instrument in use. Anyway, for weakly carbonated samples (<= 1.7 g/L CO_2) I see an advantage for EasyDens compared to the hydrometer and the popular Brix refractometers that are used by hobby brewers.

The oscillating U-tube in EasyDens is constructed in a way that the U-shape is in an upright position. During the measurement the freed gas gathers in the upper part of the U. In the meantime the measurement is done in the lower part of the U-tube which is not affected by the CO_2. I have to admit that is very clever. Modern beer measuring stations don't have this kind of construction for the oscillating U-tube. Here, the U of the oscillating U-tube points to the left and it is assumed that samples are degassed prior to measurement

EasyDens takes the same line when it comes to the way the sample is transported into the measurement cell. The sample container or rather the syringe is inserted upside down. Freed CO_2 gathers in the upper part of the syringe and hence never makes it into the measurement cell of EasyDens. Without a doubt, this concept was well planned and thought through.

Furthermore, the background lighting during the measurement provides a free view on the sample. If you discover "inconsistencies" in the measurement cell the actual sample can be replaced by a new 2 mL dose from the syringe and the measurement can start from zero.

Filtering samples - yes or no?

In general, no. The turbid/clear comparison of wort, "green beer" and finished beer samples shows that there is no deviation that exceeds the range specified by the manufacturer, no matter how unfavorable the circumstances. In the course of testing it could only be determined that massive turbidity due to yeast has a bigger influence on the measurement results than "comparable turbidity" caused by starch or protein. For the sake of completeness it should be mentioned that "comparable turbidity" is a purely subjective characterization. An instrument to measure turbidity was not available at any time.

Tips for degassing of samples - "syringe degassing"

The syringe[14)] with a total volume of 6 mL is more than suitable to degas a sample. For that purpose draw up the 5 mL of sample and if necessary warm it for a moment in your closed hand. After that you seal the tip of the syringe with your finger and pull up the syringe completely. With this procedure negative pressure develops in the syringe and you can watch as the carbon dioxide gets freed. You need to push out the formed foam and repeat the procedure. That's enough to measure without further problems, even when the sample is beer with a CO_2 content around 5 g/L.

Conclusion

With EasyDens Anton Paar offers a high-precision instrument to measure density and extract content especially for hobby brewers. The instrument is based on the oscillating U-tube technology. It is small, easy to handle, works with small sample volumes, is easy to maintain, comes with an automatic temperature compensation for °P and transfers its measurement results via Bluetooth to the mobile phone app.

Density measurement with the oscillating U-tube method implies some sample preparation for turbid and non-degassed wort and beer samples which does not really go with the mentality of hobby brewers. The repeatability and precision of density measurement with EasyDens as stated by the manufacturer were examined in this article.

The testing series shows that EasyDens is interacting reliably in the everyday business of breweries and is delivering trustable results for measured values that are selectable any time.

Like any other density meter EasyDens reacts to the samples' quality with a change in the measurement results but not in the way the built-in precision technology would make you think. This is true, thanks to the smart construction of the instrument and the way the sample is put into the measurement cell.

An extensive sample preparation is not necessary. Clear and turbid wort, "green beer" and finished beer samples can be measured in much better quality than the specifications of Anton Paar suggest (repeatability and precision). Also very weakly and weakly carbonated samples are measured reliably while correct reading of hydrometers using comparable samples is difficult.

The automatic temperature compensation, the free view of the sample in the lighted measurement chamber and the digital display of measurement results further support the brewer during the measurement. With an oscillating U-tube you have a measurement technology at hands which does not react to color.

In the complete testing period of about 4 weeks there were never any problems with the Bluetooth connection, the app never crashed, the battery was never empty and there was nothing to calibrate. The German instruction manual with the illustrated flyer adds to the good overall impression. The fact that the sample is injected into the instrument with a syringe leaves the decision to the sample taker whether the sample should be taken sterile or not. One hundred pieces of such sterile packed syringes cost about 3 € in the laboratory specialized trade.

High precision and fun in the measurement of extract don't have to exclude each other in the beer production. Anton Paar shows how it's done with just one instrument and the smallest sample volume.

Acknowledgment

In the name of brau!magazin I want to thank Anton Paar for the provision of the instruments, reagents and corresponding documents that were necessary to write this article. Special thanks go to Gebhard Sauseng of Anton Paar who was always open to criticism and willing to go the extra mile.

Declaration of conformity

All measurements were done without a second or third party involved. The measurement results are mentioned in this article in the way I read them from the instruments, as you can see in Appendix B.

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Appendix A: List of reagents

1) Bi-distilled water in laboratory quality

2) Distilled water, commercial, demineralized according to VDE 0510

3) Household sugar, commercial, individual packaging in 5 g portions, so called "sugar sticks"

4) Pure ethanol 96.3 %, to squeeze out the rinse water

5) Rotilabo folded filters, cellulose, TYP 113 P.
For filtration there was 6) added

6) Diatomaceous earth "rough"

7) Dry yeast

8) Hops, Hallertauer Taurus, TYP 90, 15.3 % alpha acid

Appendix B: List of instruments

9) Hobby brewer hydrometer, 0 to 20 %mas, without temperature display and reading value correction, reading “below” is assumed, reference temperature 20 °C, scaling 0.25 %mas

10) Calibratable hydrometer, 0 to 7 %mas, with temperature display and reading value correction, reading “below”, reference temperature 20 °C, scaling 0.1 %mas

11) Calibratable hydrometer, 7 to 14%mas, with temperature display and reading value correction, reading “below”, reference temperature 20 °C, scaling 0.1 %mas

12) Anton Paar, EasyDens, oscillating U-tube density meter, with temperature compensation for the unit °P (%mas)

13) Anton Paar, DMA 4500 M, high-precision oscillating U-tube density meter (0.00005 [g/cm^3]), with temperature compensation for all available units.

14) Luer Solo, 5 mL syringe scaled (6 mL gross), sterile, single packed

15) Kitchen scale, household type, 0 to 5000g, resolution 1g

16) Magnetic stirrer, Heidolph, MR 3001

17) Incidentals like Erlenmeyer flask, graduated cylinder 350 mL, hopper, measuring cup, etc.

Appendix C: Acronyms and definitions

18) Weight percent as description of a mass fraction in a solution. The mass fraction specifies the portion of mass of the dissolved substances in proportion to the mass of the solution. Most of the time the mass fraction is given in percent (mass percent %mas). Example: 10 g sugar/ 100 g solution = 0.1 = 10 %mas = 10 °P. In English-speaking countries also w/w[%] (weight by weight) or in colloquial German as GG[%] (weight/weight percent).

19) Beer hydrometer or colloquially “spindle”: A density meter (saccharometer, areometer, hydrometer) which displays the concentration of a sugar solution in weight percent or mass percent. For the brewer the hydrometer is the measuring instrument number one. With a beer hydrometer the brewer controls the whole production process from extraction to fermentation.

20) Apparent extract E_S [%]. Is often associated with a reading value for more or less fermented samples displayed by a beer hydrometer. Colloquially it is also called “residual extract”. The attribute “apparent” shows that the beer hydrometer is measuring in a substance its not suitable for (the beer hydrometer is calibrated for pure sucrose solutions). The alcohol content that results from fermentation influences the reading value for the extract content so that a direct comparison with a

sugar solution of the same concentration is not possible. The brewer is not taking this into much consideration, he or she just names the reading value “apparent”.

21) Density: The density of a sample is defined as its mass divided by the volume (DIN 1306). Since the volume of a sample changes with the temperature, density is a temperature-dependent measured value. Density usually is specified by the dimension g/cm^3 or in kg/m^3. The brewer prefers - not without reason - the “relative” densities. The definition of a “relative” density is a little different:
The “relative” density is the ratio of the mass of a certain fluid volume with temperature T1 to the mass of the same volume of water with temperature T2. The density SG (specific gravity) is a representative of this kind. A ratio constructed like this has no dimension and is per definition not a density ratio. Mostly “relative” densities describe the weight ratio of two fluids, not the interdependency of mass and volume.
For the sake of completeness: *SG*, Specific Gravity (“relative” density) is a dimensionless density value described as the ratio between the density of a certain substance and the density of water at a certain temperature. The “certain” temperature for water in connection with SG is assumed as being 4 °C. quote (engineeringtoolbox.com):
„…it is common to use the density of water at 4 °C (39 °F) as a reference since water at this point has its highest density of 1000 kg/m3 „. The Anglo-American brewer interprets the measured value SG the same way as the German brewer does with the value column “density 20/4” within the Plato table[25)].

22) Repeatability: This is the capability of a tester to constantly repeat the same measurement of the same sample using the same instrument under the same circumstances. Repeatability and reproducibility are two components which account for the precision of a measurement system. See link in note[23)]

The precision of an instrument is defined as “degree of consistency between the displayed and right value”. An instrument is exact when it has a high precision as well as a high degree of accuracy. (https://de.wikipedia.org/wiki/Richtigkeit)

24) Original wort: The original wort in Plato °P describes the sum of dissolved substances resulting from malt and hops in (brewing) water before fermentation. The dissolved substances mainly consist of degradation products from the starch due to malt or grain, but also of protein elements, vitamins, minerals and in low amounts substances that get into the wort by adding hops. The sum of those dissolved substances is also described as extract or extract content. The unit of original wort is Plato °P. The °P describes the mass fraction [g/100g] of dissolved extract in the wort before fermentation. The original wort in Plato °P is a fixed value which is defined in the brewery and doesn’t change when yeast is added (fermentation --> extract degradation). The hobby brewer is quite laid-back with the value Plato °P:
It doesn’t matter in which substance the hydrometer is held into, the reading value of the hydrometer is displayed in °P. This is not correct for wort that contains yeast. The measurement result of fermented wort is for logical reasons described as “apparent extract[20)].

25) Plato table: Meindl, Otto, Nürnberg, Verlag F.Carl, 1921: „*Tafeln für die Malzanalyse. Berechnet nach der Tafel der Normaleichungskommission*“
This reference work is found in every brewery.. In it information can be found about

“relative density ”[21)] of sucrose solutions in relation to extract concentration in g/100 g(°P) or in g/100mL. The brewer needs information like this when he has to calculate the amount of malt to be added. In the numerator of this formula the planned original wort value needs to be multiplied with a certain density. The Plato table knows which density value it takes.

Figures

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