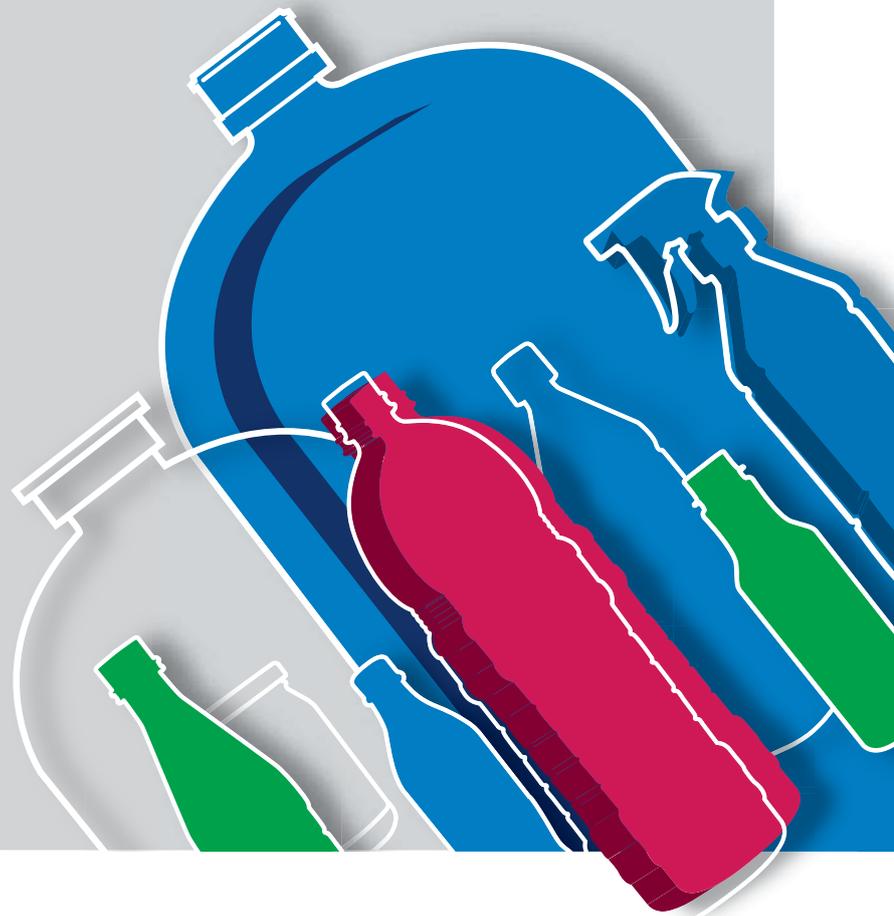


## Flavour stability of beer in Petainer Kegs

An investigation into the impact of  
aging on the quality of beer in PET  
Petainer Kegs

A white paper prepared for Petainer  
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# 1 Definition of task

Specialist plastics packaging technology business Petainer has developed a new and innovative disposable keg - the Petainer Keg - which can be used for the transport of beer, wine or other beverages. Made from fully recyclable PolyEthylene Terephthalate (PET), it is a lightweight disposable alternative to the commonly used stainless steel keg.

This white paper reports the results of a detailed investigation into the flavour stability of beer in Petainer Kegs.

The following parameters were monitored:

- Flavour stability after forced aging
- Performance of the keg during three weeks sea transportation (simulated)
- Flavour stability after a three weeks sea transportation (simulated)
- Development of a light struck flavour by direct sun insolation
- Flavour stability during a nine month storage period

Precise descriptions of the different tests and assessment methods follow in chapter 3. For comparison with the beer in Petainer Kegs, sensory tests were made with beer in stainless steel kegs. For analysis of the light struck flavour 0.5 litre NRW glass bottles were used.

## 2 Specifications of the Petainer Keg

The Petainer Keg is a PET container which is available in 15, 20, 30 and 40 litre versions. More versions are currently being developed for particular applications.

The container itself is made from PolyEthylene Terephthalate (PET), which is enhanced by additives (blend-technology). Using the additives improves the container wall's ability to keep CO<sub>2</sub> inside and prevent oxygen from entering the container. A brown colorant in the container wall shields the contained product from light and insolation.



*Figure 1: Petainer Keg, consisting of PET container, fitting and coupling head.*



*Figure 2: Empty 20 litre Petainer Kegs with flat type fittings.*

In addition to the PET container the Petainer Keg has a fitting and a lance. Both of these parts are also made of plastic. The Petainer Keg is stored in a cardboard carton which gives additional protection from mechanical impacts and direct insolation. The carton also simplifies transportation and stockpiling of the Petainer Keg.

All the materials used meet the requirements of international directives for packaging materials that have contact with foods.

The Petainer Keg can be integrated into common draft beer tapping systems and the contents are dispensed, like those in a metal keg, through the closure by a gas supply connected through the closure.

Once it is empty the Petainer Keg can be handed over for waste processing. Its structure makes it possible to feed its materials into the normal plastics recycling infrastructure after separating the individual components.

For roughly 90 per cent of tap head types worldwide there are Petainer Kegs available with applicable fitting types.

The Petainer Kegs used for the studies depicted in this text were filled with beer in a brewery in northern Germany.

All tests reported in this white paper were conducted using Petainer Kegs with a nominal volume of 20 litres and flat type fittings.

### 3 Materials and methods

The containers used throughout the tests were described in chapter 2. In the individual tests which will later be depicted only filled 20 litre containers with flat type fittings were used. The kegs were filled with beer produced according to pils-type standard (see table 1). CO<sub>2</sub> content was at 5.0 g/l, oxygen content during the filling was at 0.09 mg/l.

Density	1.00665
Original extract [%]	11.42
Real extract [weight. %]	3.93
Apparent extract [weight. %]	2.17
Alcohol [vol. %]	4.91
Degree of fermentation [%]	80.96
pH	4.39
Colour [EBC]	5.3
Bitter units [EBC]	28.6

Table 1: Beer Analysis

A KHS Innokeg Till Lab filler was used to fill the Petainer Kegs. Preload pressure amounted to 1.6 bar, during the filling process beer pressure amounted constantly to 3.0 bar while return gas pressure was set to 1.4 bar.

Graphics 3 and 4 indicate the exact step sequence of the filling procedure.



Graphic 3: KHS filler sequences for Petainer Keg filling

VERF. SCHRITT	LAUFZEIT	PRUFZEIT
FULLEN	39,93 sec.	1,01 sec.
DRUCKENTLASTEN	2,00 sec.	0,01 sec.
KOPF AUSBLASEN	1,01 sec.	0,01 sec.
WARTEN	1,51 sec.	0,01 sec.
DURCHBLASEN	1,51 sec.	0,01 sec.
ENDE	0,01 sec.	0,01 sec.
CIP	0,01 sec.	0,01 sec.
CIP	0,01 sec.	22,99 sec.

**Graphic 4: KHS filler sequences for Petainer Keg filling.**

For comparison purposes empty 20 litre steel kegs which had previously been cleaned with a common keg plant were also filled with the same beer using the KHS test filler.

The Petainer Kegs used in these tests contained normal sterile air before starting the filling process and were then flushed with CO<sub>2</sub> before filling them with beer. The standard steel kegs therefore showed a technological advantage at this point because they were steamed before the filling process and then filled with CO<sub>2</sub>. The steaming procedure minimises the oxygen content in the keg. After the kegs were filled with beer there was almost no oxygen (which can cause oxidation of the beer) left in the kegs' headspaces.

### 3.1 Accelerated aging

To make reliable predictions on flavour stability, bottled beer is usually subjected to forced aging. To simulate three month aging the beer is shaken for 24 hours (simulating transportation) and stored afterwards for four days in the dark at 40°C. This makes it possible to compare its taste to beer which has not been forcefully aged to get early data on flavour stability.

Forced aging is uncommon in the draft beer sector but experiments with this were undertaken during this survey.

Filled Petainer Kegs and steel kegs were shaken for a whole day using a special device. Then the kegs were stored at 40°C for 4 days in a temperature-controlled room. Afterwards taste was compared. Beer that had undergone the forced aging in steel kegs was compared to force-aged beer in Petainer Kegs and also fresh beer from the same type of containers.

## 3.2 Simulation of a three weeks sea transportation

To realistically simulate effects of sea transportation, stockpiled Petainer Kegs were constantly rocked slightly in a special device during the whole simulation period to implement mechanical forces that can influence the barrel.

As high temperatures can occur during sea transportation the Petainer Kegs with the device were subjected to increased temperature in an air-conditioned room. At first this room's temperature was raised to 60°C for 24 hours. For the rest of the three week test period the temperature was held at 35°C. The stainless steel kegs used for comparison were treated equally.

For tasting, beers subjected to the simulated transportation as well as beer in kegs that had not undergone simulation (for comparison) were tested and assessed according to the DLG-scheme and according to the procedure developed by Dr Eichhorn.

## 3.3 Light struck flavour

While being stored, delivered and connected to the tap the Petainer Keg is usually kept in its solid cardboard carton. Despite this, a brown colorant is integrated into the keg material for absorption of light of certain wavelengths to prevent the development of a 'light struck' flavour in the keg contents.

To discern the extent of light struck flavour that develops despite this measure, a Petainer Keg was subjected to direct insolation without its cardboard carton for 10 hours. There is no standardized measurement for the intensity of a light struck flavour. To make comparison possible 0.5 litre NRW glass bottles without labels and filled with the same beer were exposed to the sun over the same period.

## 3.4 Six month storing

The filled Petainer Kegs were stored in their cardboard cartons at about 20°C room temperature. After one, three and six months taste tests were conducted at which beer from Petainer Kegs was compared to beer from steel kegs. Both were assessed according to the DLG-scheme as well as according to the procedure developed by Dr Eichhorn.

## 3.5 Tasting

A repeat determination was performed at all tastings. The tasting team consisted of people with the appropriate sensory skills and training.

## 3.6 Tasting according to DLG test

For assessment of the beer quality the five item DLG test was used. The DLG tasting was undertaken for both the fresh and the aged beers.

## 3.7 Aging test developed by Dr Eichhorn

The taste test developed by Dr Eichhorn rates the aging of beers in categories of flavour, drinking and bitterness with the following scale in half grade steps:

- 1 = fresh
- 2 = slightly aged
- 3 = strongly aged
- 4 = extremely aged

The testers also rate the aged beer's acceptance in steps of 20 per cent (100, 80, 60, 40, 20, and 0 per cent). The total grade is summed up from the individual criteria, with 'flavour' and 'drinking' multiplied by 2 before being added to the final grade. The tastings were conducted with the fresh and the aged beers by people with the appropriate sensory skills and training.

In contrast to the DLG evaluation the aging 'taste score' according to Eichhorn starts with 1 for a good quality up to 4 for a dramatic aging. In the DLG a perfect quality is rated with 5.

The tastings for rating the beer quality and aging were conducted as shown by graphic 5.

Datum: \_\_\_\_\_  
 Versuch: \_\_\_\_\_  
 Verkoster: \_\_\_\_\_

**Verkostung nach DLG:**  
 Bewertung in Halbnotenschritten von 1 bis 5  
 Bitte Aromaeindruck angeben!

Nr.	Probe	Geruch	Trunk	Volm.	Rezenz	Bittere

**Alterungsverkostung:**  
 Bewertung in Halbnotenschritten:  
 1= frisch  
 2= leicht gealtert  
 3= stark gealtert  
 4= extrem gealtert

Die Akzeptanz bezieht sich  
 nur auf die Alterung des  
 Bieres!

Nr.	Probe	Geruch	Trunk	Bittere	Akzeptanz [%]						
					100	80	60	40	20	0	

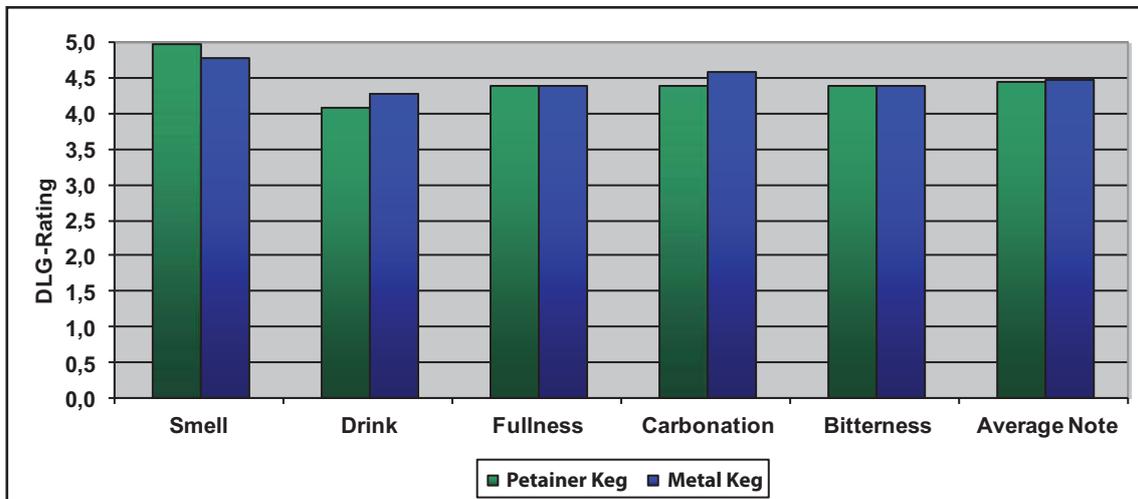
Graphic 5: Tasting scheme.

## 4 Results and discussion

### 4.1 Evaluation of comparison

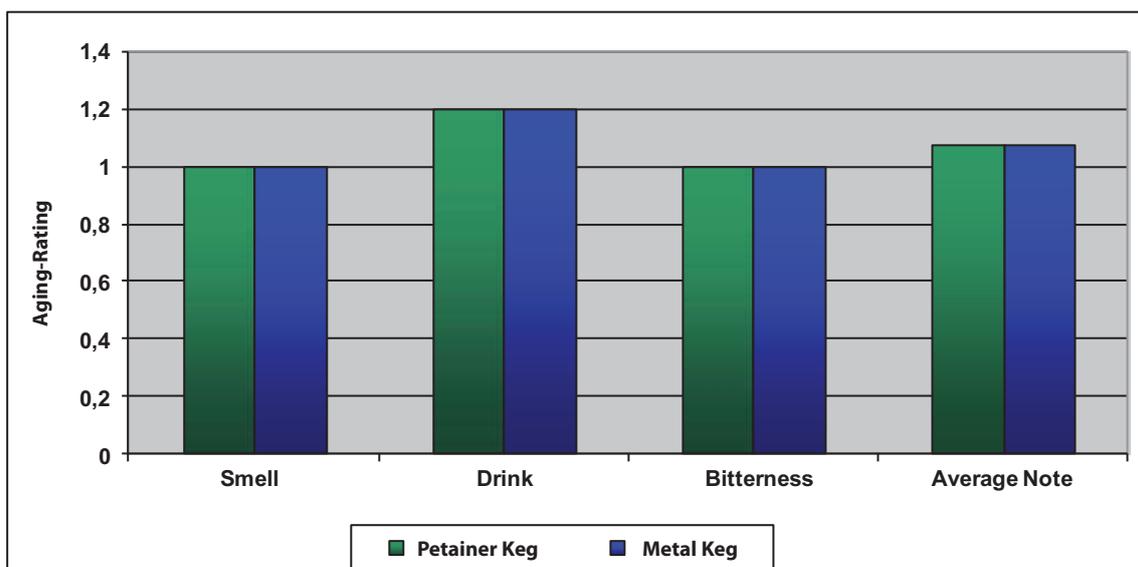
Seven days after the kegs were filled a tasting was conducted comparing beer from the metal keg with beer from the Petainer Keg.

At this point no significant differences could be detected and the beer from both containers was rated identically according to the DLG grading.



Graphic 6: DLG rating of the fresh beers.

In the course of aging tasting both beers were rated the same (see table 3). Acceptance of both beers was at 96 per cent each.

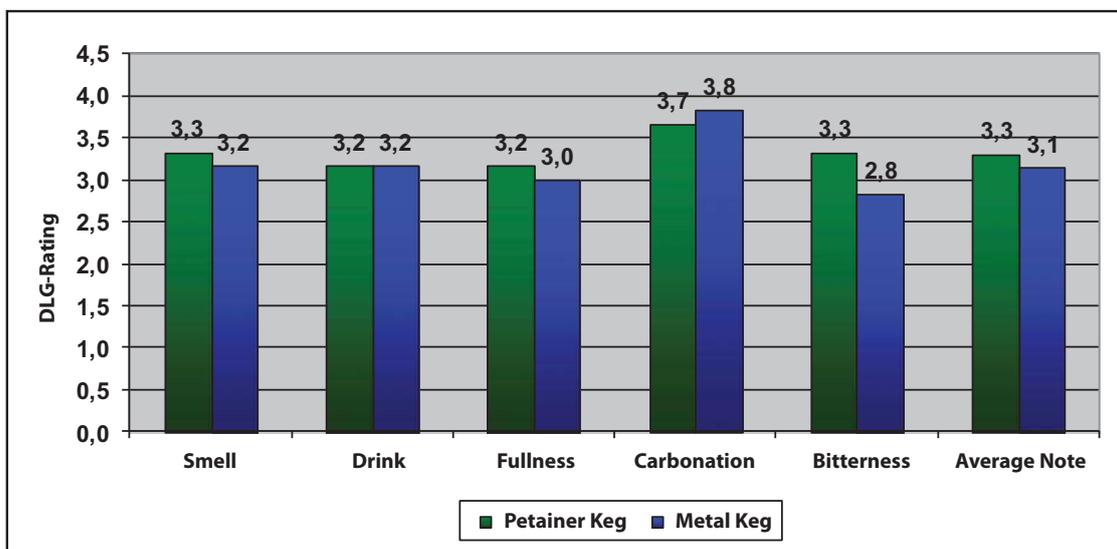


Graphic 7: Aging rating of the fresh beers.

## 4.2 Forced aging

After the forced aging the beers from both types of containers were rated almost identically by the testers. A slight aging was recognizable in both beers by smell and also by taste as oxidation. According to the graphic only small differences occurred during the DLG-grading, although the beer from the Petainer Keg was rated slightly better than its steel barrel counterpart.

However, a remarkable difference was observable when comparing the fresh and the forcefully aged beer. The 'bitterness' of the steel barrel beer was impaired during the forced aging. It was rated as a little bit "edgy" while the bitterness of the Petainer Keg beer was just as soft as in the fresh beer.



Graphic 8: DLG rating of the forced aged beers.

Shaking the beer for 24 hours directly after filling and the following warm phase lead to a faster oxidation because of oxygen present in the beer and the barrel. Before the scavenger can have a lasting effect, oxygen that entered the barrel during filling partly oxidises the beer.

## 4.3 Performance of the keg during three weeks sea transportation (simulated)

The Petainer Kegs endured the three weeks of being exposed to augmented temperatures and constant movement without noticeable outer alterations. This is remarkable as the internal pressure of a keg with a CO<sub>2</sub> content of 5.0 g/l will be around 6 bars at the maximum employed temperature.

The fitting seal had been moved a small amount by the 60°C temperature. However, this effect is reversible - after cooling down, the fitting and seal returned to a 'factory-fitted' condition. The function of the fitting (automatic pressure release after tapping) and the tightness were not impaired by the high internal pressure and no CO<sub>2</sub> loss could be observed.

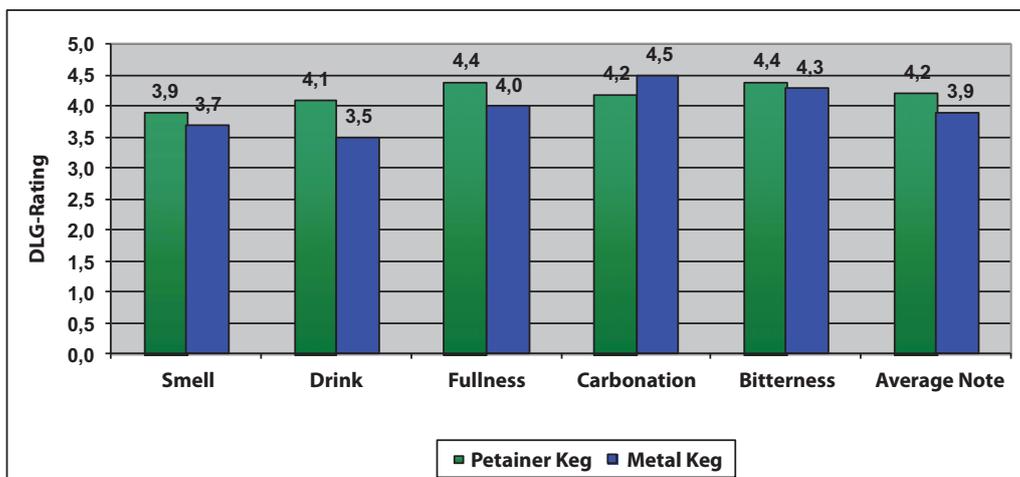
At this point it must be emphasised that the test's 60°C temperature was meant to simulate an extreme case. In practice Petainer Kegs should not be exposed to temperatures above 30°C or situations with a higher container pressure than 3.0 bar.

## 4.4 Flavour stability after three weeks sea transportation (simulated)

The beers from the containers subjected to simulated transportation showed notable interesting differences.

Beer from the metal keg was rated clearly worse in most aspects of the DLG rating than the beer from the Petainer Keg. This disparity is especially large at drinking.

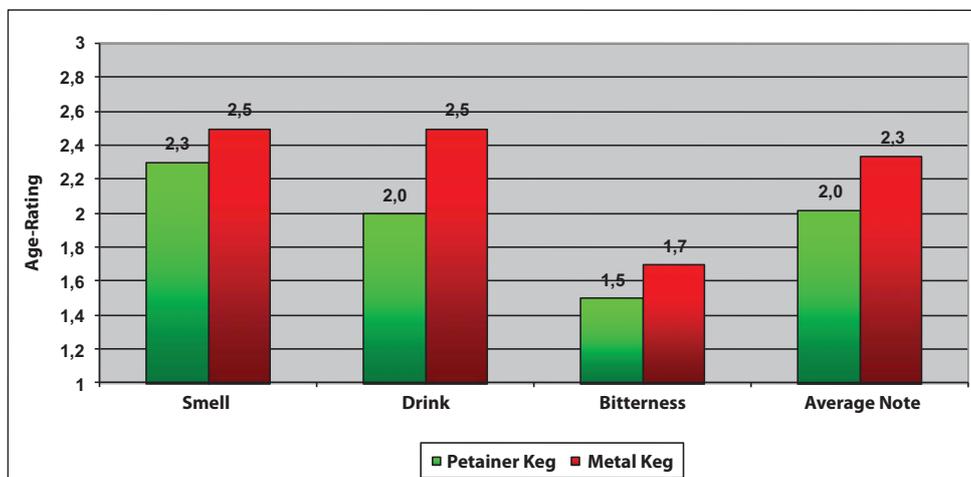
The Petainer Keg's carbonation was rated nearly as highly as the metal keg's carbonation. This shows that there is no significant loss in pressure during transportation with warmer temperatures.



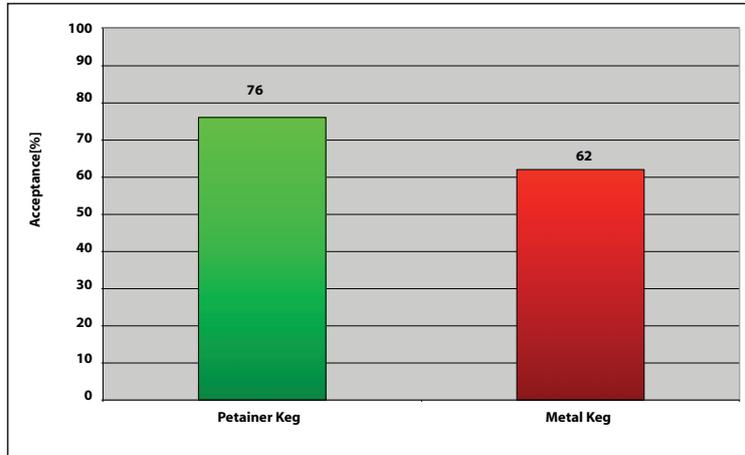
Graphic 9: DLG ratings of beers from containers with simulated sea transportation.

In the context of aging tasting, the results of the DLG rating were confirmed. Beer from the metal keg was rated as more strongly aged in every category than beer from the Petainer Keg. As shown by graphic 10 there was a stronger aging noticeable, especially at drinking.

Analogous to graphic 11, the acceptance of beer from the Petainer Keg is at 76 per cent and thus much higher than acceptance of beer from the metal keg.



Graphic 10: Aging rating of beers from containers with simulated sea transportation.



*Graphic 11: Acceptance of beers from containers with simulated sea transportation.*

These outcomes clearly demonstrate that the Petainer Keg has a slower oxidation of its beer than the metal keg. This confirms the already existing insight that the scavenger integrated into the Petainer Keg not only hinders oxygen from invading the container but also draws oxygen from the beer that enters when the keg is filled.

Thus the Petainer Keg has a big advantage in quality over the metal containers with regard to oxidation. This effect will be strongest during transportation of beer over long distances and will allow long 'best before end' dates.

## 4.5 Development of a light struck flavour

There is no way of rating a light struck flavour quantitatively. Everyone taking part in the taste tests gave another subjective statement about the grade of a light struck flavour he or she recognised. In every case, the light struck flavour of the bottled beer was experienced as much more obvious than that of the beer from the Petainer Keg.

There are two possible explanations for this. On the one hand, the 0.5 litre NRW glass bottle has proportionally more surface area per unit of content than the keg - more light can enter the bottle and have an effect on the beer (table 2).

On the other hand it was shown in studies that PET absorbs more light than correlating glass.

	content [litre]	surface area [dm <sup>2</sup> ]	dm <sup>2</sup> /litre
0.5 litre bottle	0.5	4.5	9
Petainer Keg	20	40.5	2.025

*Table 2: Comparison content to surface of a 0.5 litre bottle and the 20 litre Petainer Keg.*

## 4.6 Flavour stability during a six month storing period

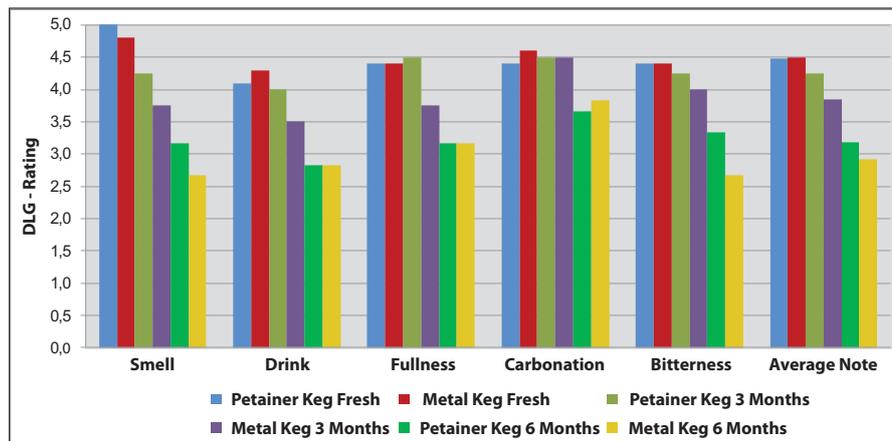
In terms of flavour stability, the beers from both container types showed interesting differences during the six month observation period.

At the three month DLG tasting, beer from the Petainer Keg was rated better in every category than beer from the steel keg and the carbonation was at the same level. The grade given to the Petainer Keg beer at this point was 4.3 while it was only 3.8 for the steel keg. The bitterness of the steel keg beer was experienced to be slightly less good than that of the Petainer Keg beer - there was a noticeable lingering bitterness. All-in-all, the aging process here was at an advanced state which was mainly recognisable by a type of oxidation.

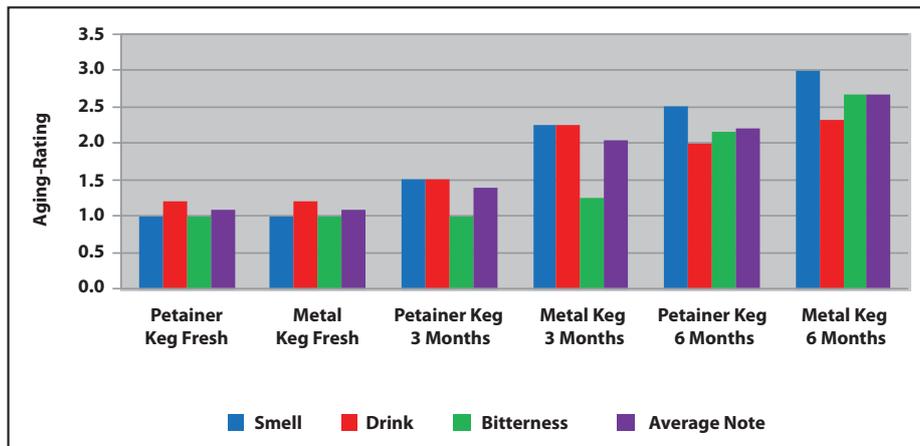
At the tasting after six months storage, the Petainer Keg's advantage was a little bit lower with a grade of 3.2 compared to 2.9 for the steel keg. The smell of the beer from the Petainer Keg was rated better but in drink and fullness both beers were at the same level. The carbonation at the same time was rated a little bit lower for beer from the Petainer Keg. Possibly it experienced a small loss in CO<sub>2</sub> through permeation processes during the long storage time.

Just as with the tasting after three months, there was a negatively-perceived lingering bitterness of the metal keg beer that was not present in the Petainer Keg beer.

It appears that the aging of the metal keg beer has an impact on the substances which produce bitterness in the beer. As this does not occur in the Petainer Keg it may be the case that this process is prevented by the integrated scavenger.



Graphic 12: DLG rating from the fresh and aged beer in Petainer Keg and metal keg.



*Graphic 13: Aging rating from the fresh and aged beer in Petainer Keg and metal keg.*

Overall, the Petainer Keg’s advantage is especially large at the tasting after three months. After six months the difference between beers from the metal keg and Petainer Keg is no longer so large.

## 5 Conclusion

In the course of the executed tests no issues were encountered which would be a 'downside' in the use of Petainer Kegs. The Petainer Kegs even stood up to the high temperatures and movement of simulated transportation.

Remarkably positive is the beer's flavour stability in the keg. During the six month observation period the Petainer Keg beer earned better grades in most tastings and criteria than beer from a conventional steel keg. The reason for this is probably the integrated scavenger which not only prevents oxygen permeation from outside into the keg but also reduces the amount of oxygen already contained by the beer after filling the keg. This is not possible for the steel keg.

During the aging tasting the changing bitterness of the beer from the steel keg was particularly noticed - there was an unpleasant lingering bitterness.

It is therefore clear that oxidation processes relying on or induced by oxygen are slowed down and reduced by the scavenger in the Petainer Keg. The beer's other aging processes and its chemical-physical stability cannot be improved by the scavenger.

Overall, the Petainer Keg proved to be a superior alternative to the conventional steel keg in regards to the quality of the beer, even with prolonged storage time.

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