Viscosity of a selection of Aquavits at different temperatures

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ABSTRACT

The viscosity of aquavit is one parameters used to describe its qualities. However, popular words like "good viscosity", "mouthfeel" and other sensory ratings seems rather subjective in order to understand key sensory profile of the products.

Aquavit is today normally consumed at room temperature, but some people want it cold.

The viscosity of a selection of Norwegian, Swedish and Danish aquavit were measured at 20 °C and 4 °C at varying shear rates.

The results show the expected general temperature effect that the viscosity generally decrease with increase in temperature. There are also relatively large differences in viscosity between the different brands, especially at the lower shear rates tested, and the relative viscosity between the different brands are different at the high and the low temperature.

The aquavits split into six significantly different groups at 20 °C while they only split into three groups at 4 °C. The relative differences are therefore larger at the higher temperature.

Power law modelling indicate that all of the aquavits are slightly shear thickening, or dilatant.

INTRODUCTION

Ethanol is commonly utilized to compose various beverages and flavored liquors. An increased attention has been paid to flavoured beverages the last decades.

Flavoured mixes of ethanol and water, like Aquavit and Vodka, contain herb extracts and essences, plant distillates, fruits and their juices, and volatile aromas[1].

Aquavit is distilled from either grain or potatoes, and usually bottled without aging. After distillation, it is flavoured with herbs, spices, or fruit oil. Commonly seen flavours are caraway, cardamom, cumin, anise, fennel and lemon or orange peel. Dill and grains of paradise are also used.

The recipes and flavours differ between brands, but caraway is typically the dominant flavour. Aquavit usually has a yellowish hue. But this can vary from clear to light brown, depending on how long it has been aged in oak casks (Norway)[2] or the amount of colorant used. Normally, a darker colour suggests a higher age or use of young casks, though artificial caramel colouring is permitted. Clear aquavit is called taffel; - it is typically aged in old casks that do not colour the finished spirit, or not aged at all.

Mouthfeel and texture are major determinants for consumer's acceptance of, and preference for beverages. Viscosity, density and surface tensions are essential rheological properties of liquids. But there are numerous areas where rheological data are needed in the food and beverage industry, like;

- determining ingredient functionality in product development.
- process engineering calculations which involve a wide range of equipment such as pipe-lines, pumps, filtration, clarification and others.
- intermediate- or final product control.
- shelf life testing and evaluation of texture[1, 3]

Texture is related mostly to solid and semi-solid foods. Mouthfeel deals with the properties perceived at the time at which solid, and semi-solid or liquid foods like beverages are placed in the mouth and kept there until they are swallowed. Interesting in this context is also the changes to chemical senses of taste and smell that accompany ageing. Textural attributes of beverages are unique characteristics, which contribute to overall enjoyment of the beverage where attributes such as "thickness" is a commonly used term[4].

Aquavit typically contains 40% alcohol by volume. The EU has established a minimum of 37.5% ABV (Alcohol By Volume) for aquavit to be named as such[5]. Aquavit is a typical Nordic liquor, which seldom is produced outside the Nordic countries.

Physical viscosity, density and yield stress are therefore interesting to give a more comprehensive and exact profile of the sensory properties of the fluids.

The objectives of the studies reported in this paper was to:

- investigate and compare the viscosity of a selection of Norwegian, Swedish and Danish Aquavits
- investigate consumption temperature effects in viscosity by measurements at 20 °C and 4 °C at varying shear rates.

MATERIALS AND METHODS

Aquavits

The 10 different Aquavit tested given in Fig. 1, were purchased from The Norwegian Wine Monopoly (Vinmonopolet). This is a Norwegian government-owned alcoholic beverage retailer. It is the only company allowed to sell beverages containing an alcohol content higher than 4.75% in Norway.

Figure 1: The 10 different Aquavit tested, from left to right – Gammel Opland (N), Lysholm Linje (N), Gilde Taffel (N), O.P.Anderson (S), Gammel Porsgund (N), Aalborg Dild (D), Aalborg Jubilæum (D), Prima Skåne (S), Løitens Sommer (N), Simers & Co Taffel (N) and Løitens Sommer (N). (D- Denmark, N- Norway, S- Sweden).

Instrumental analysis and experimental set-up

The Physica MCR301 rheometer (Paar Physica, Anton Paar, Stuttgart, Germany, 2010) fitted with a CC27 Bob/Cup. The viscosity of the products was measured by rotational viscometry.

Rotational shear rate sweeps from 1 1/s to 500 1/s were recorded at 4 °C and 20 °C.

Statistical treatment

Minitab 16 using one-way (unstacked) ANOVA with confidence level 95% with grouping analyzed the results. The method was based on Tukey with a family error rate of 5%.

RESULTS

The statistical analysis showed that the aquavits grouped into three different groups (A, B and C) at 4 °C and into six different groups (A, B, C, D, E and F) at 20 °C.

Typical results of the viscosity determination with the Paar Physica rheometer for the 10 tested Aquavits, are illustrated in Fig. 2, 3 and 4. All figures are focusing on viscosity as a function of shear rate.

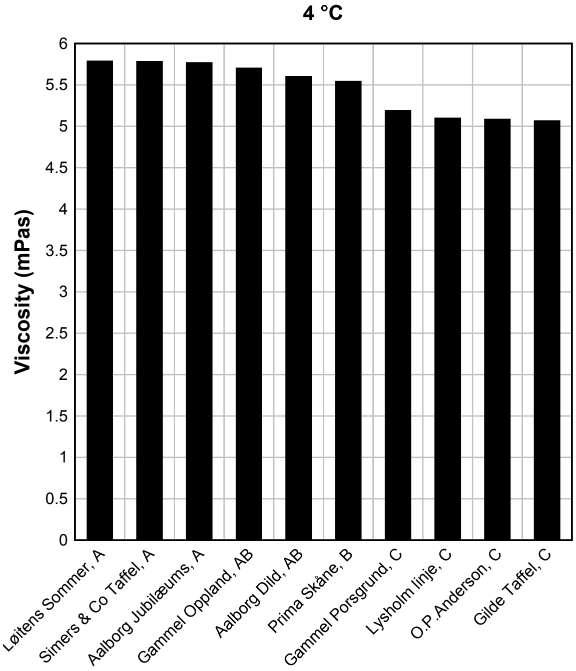

Figure 2: Viscosity at 4 °C of 10 different Aquavit measured by a Physica MCR301 rheometer fitted with a CC27 Bob/ Cup. Rotational shear rate sweeps from 1 1/s to 500 1/s.

A normalized viscosity is calculated from the relationship:

$$\eta_{Normalized} = 2\frac{(\eta - \eta_{min})}{(\eta_{max} - \eta_{min})} - 1 \qquad (1)$$

The normalized viscosity values are shown in Fig. 4.

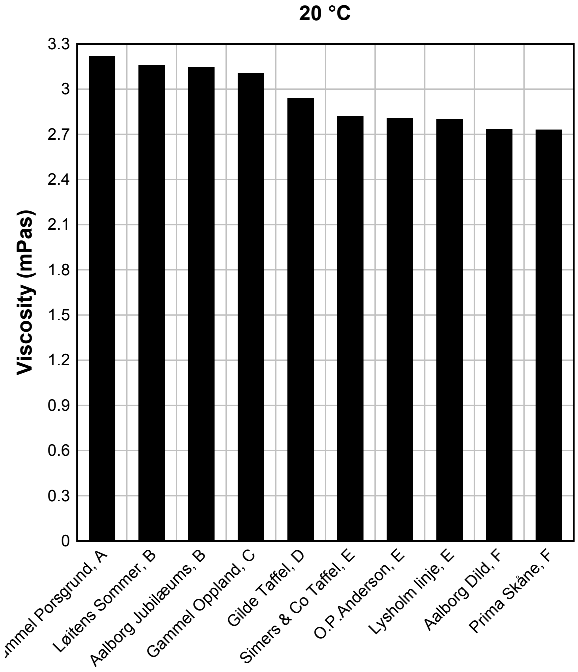

Figure 3: Viscosity at 20 °C of 10 different Aquavit measured by a Physica MCR301 rheometer fitted with a CC27 Bob/ Cup. Rotational shear rate sweeps from 1 1/s to 500 1/s.

DISCUSSION

Depending on the type of Aquavit, different storage procedures are used. One maturation procedure includes 6 months barrel storage at the Norwegian Wine and Spirits Monopoly, followed by 5 months storage at sea as deck cargo, using the same type of barrels, on a voyage to Australia and back. These conditions contribute to the specific flavor and color of this aquavit. The oak origin and the previous history of the barrel, such as whether the wood has been seasoned, charred or toasted and barrel age, etc., also affect the sensory characterization of the product[2].

In this investigation, it was of interest to measure if this special maturation also affected the rheological properties of the products, when compared to other Aquavit samples.

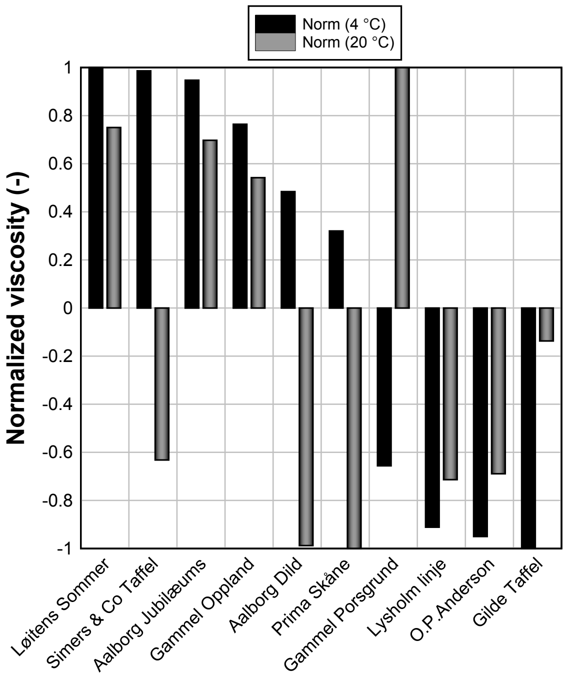

Figure 4: Normalized viscosity at 4 and 20 °C of 10 different Aquavit measured by a Physica MCR301 rheometer fitted with a CC27 Bob/ Cup. Rotational shear rate sweeps from 1 1/s to 500 1/s.

By considering the measurement results in Fig. 2 and 3, it is obvious that there are differences in viscosity between the different manufacturers and brands. This applies whether measured at 4 °C or 20 °C.

According to Fig. 2 and 3, the measurements reveals differences in viscosity between the 10 tested Aquavit samples at both 4 °C and 20 °C. It is a further significant reduction in viscosity when the temperature increases from 4 °C to 20 °C for all the Aquavits. This is of course as expected since viscosity depends on the phenomenon by which liquid viscosity tends to decrease as its temperature increases[6,7].

Looking at Fig. 4 regarding normalized viscosity at 4 and 20 °C of 10 different Aquavit, one observe that some of the samples have a fairly expected and reduced viscosity when the temperature increases. Examples of this are "Løytens Sommer (N)", "Aalborg Jubilæum (D)" and "Gammel Opland (N)".

Fig. 4 also illustrates that some samples having relatively low viscosity at 4 °C, not necessarily have the same low relative viscosity at 20 °C when the samples are compared with each other. Examples of this are "Gammel Porsgund (N)" and "Gilde Taffel (N)".

In a future perspective, it would be interesting to further investigate rheological properties both in more brands, and in brands added different spices. In addition, it is of course interesting to measure viscosity of the brands at temperatures below 0 °C, since many people still serve Aquavit directly from the freezer at -20°C.

CONCLUSIONS

The conclusions of this work can be summarized as follows:

- The viscosity of aquavits is a function of temperature and brand
- The aquavits split into six significantly different groups at 20 °C, while they only split into three groups at 4 °C. The relative differences are therefore larger at the higher temperature.
- The relative viscosity between the aquavits is a function of temperature.

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