Effect of Thickening Agents on Perceived Viscosity and Acidity of Model Beverages

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Abstract

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The effect of thickening agents – methyl cellulose, hydroxyethyl cellulose, sodium carboxymethyl cellulose, and xanthan gum – solutions on the sensory viscosity was investigated in the concentration range of 0–0.8%. The perceived viscosity was proportional to the logarithm of kinematic viscosity in the presence of citric and malic acids. The viscosity was inversely proportional to the acidity at the viscosity levels higher than 10 mm^2/s. A liquid of high viscosity thus possess lower acidity than aqueous or low-viscosity solutions. No significant differences were found between the effects of different thickening agents.

Keywords: sensory evaluation; acid taste; cellulose derivatives; model samples; viscosimeter

The consumption of packed non-alcoholic beverages has increased in all countries in recent years, including the consumption of sweetened beverages. Sugar is often replaced with synthetic sweeteners in light beverages, which can result in lower viscosity of the product. Substitution of intense sweeteners for sugar is not satisfactory when only sweetness matching is considered, other functional properties of sucrose must also be taken into account. The presence of sucrose in the aqueous phase of liquid food systems containing hydrocolloids can change their flow behaviour: the effect can be either an increase or a decrease in the viscosity of the system due to increasing viscosity of the aqueous phase or reduction in the hydration of hydrocolloid molecules, respectively (Yanes *et al.* 2002).

The viscosity of food products cannot be predicted theoretically, due to complicated physical and chemical structure (Galmarini *et al.* 2011). The role of thickening agents in beverages can be different. Sometimes consumers prefer higher viscosity corresponding to beverages containing sucrose. Therefore, thickening agents are usually added in order to increase the viscosity and replace the effect associated with sucrose. Higher viscosity is perceived in some cases as a positive factor, and can improve the flavour acceptability because it is encoded in primates as a marker of the higher energy content of food (Glaser 1986, 1993). The viscosity of beverages through the addition of thickening agents generally increases satiety ratings but this is often associated with a reduction of palatability (Mattes *et al.* 2001).

A similar attitude of consumers was observed not only in beverages, but also in fat emulsions, e.g. in mayonnaise (Štern *et al.* 2001).

The majority previous works that studied how viscosity affects perceived taste intensities attributed the decreased perceived intensities of different tastes to reduced availabilities of the tastants to

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the oral receptors. These works were done usually on salty and sweet tasting model products and fewer works were aimed at sour taste.

The acceptability of drinks is critically dependent on the acidity at which they are normally consumed and the so called 'Brix-acid ratio' is an important control parameter in the citrus industry. McBride and Finlay (1990) demonstrated that the psychophysically dominant characteristic in sugar-citric acid model systems is the acidity, which makes the greatest contribution to the overall taste intensity.

In addition to sugar, organic acids, such as citric, tartaric or malic acid, are mainly added to soft beverages to increase the sour taste and also the perception of freshness, common in fruit beverages. The presence of acids decreases the sweetness of sucrose. The interaction of tastes is influenced, however, by changes of viscosity. Increasing viscosity of the sample increased the stimulus and recognition thresholds of basic test substances, including citric acid (Paulus *et al.* 1980). Similarly like in the case of sweetness-acidity interactions, higher concentrations of citric acid reduced the perceived viscosity of the solution (Christensen 1980). It is probable that very viscous liquids inhibit the access of hydrogen ions to taste receptors, thus decreasing the perceived acidity.

The effect of methyl cellulose on the sensory rating of acidity in model samples was described (Šedivá *et al.* 2004). In this paper we studied the effect of high concentrations of common thickening agents on the perceived intensities of viscosity and acidity.

MATERIAL AND METHODS

Panellists. Sensory assessors were selected, trained and monitored according to the respective standard ISO 8586-1:993. An assessor panel composed of 11 highly trained panellists (aged 20–60, seven women, four men) from the Sensory laboratory ITC participated in this study. Each panellist had experience of two years at least in the sensory analysis, particularly with the sensory profiling and undergoes periodic revalidation and retraining.

Samples. Malic acid, p.a. (Sigma-Aldrich Chemie, Steinheim, Germany) and citric acid, p.a. (Penta, Prague, Czech Republic) were used.

Both acids 0.5% citric acid (pH 3.77) or 0.5% malic acid (pH 3.71) were dissolved in deionised water as a solvent.

Four commercial thickening agents i.e. methyl cellulose (Benecel 143-HR), hydroxyethyl cellulose (Natrosol) and sodium carboxymethyl cellulose (Blanose) were obtained from Herkules CZ (Prague, Czech Republic), and xanthan gum was a product of Sigma-Aldrich Chemie (Steinheim, Germany). Thickening agents were dissolved in an aqueous solution of citric and malic acids. Solutions contained 0.10, 0.20, 0.50, and 0.80% of the agent.

Methods. The preparation and serving of the samples were described in Šedivá *et al.* (2004). Unstructured graphical scales, constructed according to the standard ISO 4121:1985, were represented by straight lines 100 mm long. They were oriented by descriptions at the two ends of the line (viscosity: 0 = very thin, 100 = very thick; acidity: 0 = imperceptible, 100 = strongly acidic). The results were expressed in percent of the graphical scale.

Acidities of citric acid and malic acid solutions were compared by the paired comparison test (20 pairs).

Viscosity measurements. An Ubbelohde TS 1823 viscometer (Technosklo, Držkov, Czech Republic) was used for the measurements. The capillary diameters were 0.64 mm for samples containing 0.10% of thickening agents and 1.13 mm for the other tested concentrations. The temperature was 25°C. Two determinations were carried out at the same time. The kinematic viscosity of the sample was expressed in mm^2/s.

Statistical analysis. The MS Statistica 3 software (StatSoft CZ, Prague, Czech Republic) was used, the probability level was $P = 0.05$, unless otherwise stated.

RESULTS AND DISCUSSION

Test samples containing either 0.5% citric acid or 0.5% malic acid were used. Thickening agents were dissolved in an aqueous solution of citric and malic acids. Four levels of each of the four thickening agents were tested (0.10, 0.20, 0.50, and 0.80%). Kinematic viscosities of solutions are shown in Table 1. Linear regressions were tested and the respective correlation coefficients were calculated. The logarithm of sample viscosity was a linear function of the concentration in the case of methyl cellulose. In the other thickening agents the logarithm of sample viscosity was a linear function of the concentration only up to the concentration of 10 mm^2/s or slightly more. However, moderate deviations were observed at

Table 1. Kinematic viscosities of test solutions (mm^2/s)

Concentration of thickening agent (%)	Benecel	Natrosol	Blanose	Xanthan gum
0.10	1.98	2.80	5.70	4.20
0.20	3.10	9.00	22.80	11.50
0.40	9.76	9.76	209.00	149.00
0.80	50.00	50.00	699.00	721.00

higher concentrations, especially at viscosities higher than 100 mm^2/s. Nevertheless, a linear expression between the logarithm of kinematic viscosity (K) and the concentration (C in %) was still in significant agreement with experimental data in the set of all 40 samples ($\log K = 0.216 + 2.90\ C$; $N = 40$, $P = 0.95$; $r = 0.91$).

The sensory analyses were based on 13–42 determinations, carried out by 11 trained and experienced assessors; some assessors participated several times. Sensory viscosities varied in the interval of 25–92% of the graphical scale. Results obtained in the case of citric acid solutions were not statistically different from those obtained with malic acid solutions, therefore, they are treated as a single set. The dependence between the logarithm of kinematic viscosity (K) and the perceived sensory viscosity (V) was essentially of a sigmoid character, but very close to linearity (Figure 1) so that it could be considered as linear ($\log K = 0.036\ V - 0.84$; $N = 40$; $P = 0.95$; $r = 0.94$). Still some difference could be found as the increase of perceived viscosity (V) was slightly higher in the range between 1 and 10 mm^2/s, but slightly lower at higher kinematic viscosities. The multiple linear regression between the sensory viscosity (V) and the combination of kinematic viscosity (K) and the concentration of the thickening agent (C) expressed still better the course obtained in the experiments:

$V = f(\log K, C)$: $R^2 = 0.899$; $N = 40$; probability level of significance: $P < 0.0000$

$C = f(\log K, V)$; $R^2 = 0.829$; $N = 40$; probability level of significance: $P < 0.00000$

The relationship between the sensory viscosity and the acidity was nearly linear ($r = -0.83$), but in more detail, it consisted of two stages. At the viscosities between 1 and 10 mm^2/s (corresponding to the range of sensory perceived viscosities between 25% and 50% of the scale), the increase of viscosity had only a small effect on the acidity. At higher viscosities, however, the acidity decreased proportionally to the increasing kinematic viscosity (Figure 2). A similar relationship was obtained between the sensory viscosity and the acidity. Acidities of citric acid solutions were significantly lower than acidities of malic acid solutions (determined by the sign test, 20 pairs, 16 positive and 4 negative; $P = 0.95$). These differences were, however, only moderate, and not statistically significant for the evaluation of viscosity/acidity interactions. No significant differences were observed among the solutions of different thickening agents (determined by rank test, $P = 0.95$, 8 sets of cases, evaluated according to Kramer; sums of rankings 16–24).

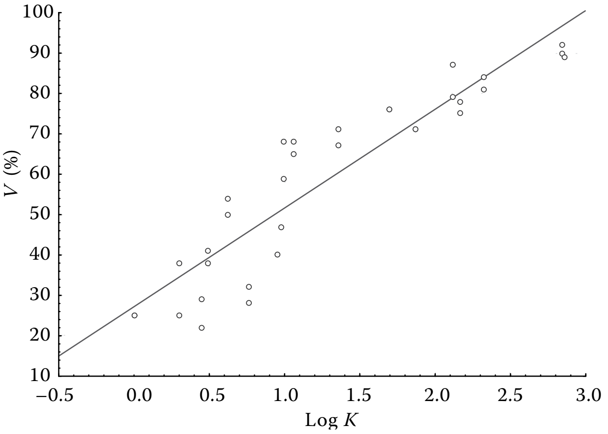

Figure 1. Relation between the kinematic viscosity K (mm^2/s) and the sensory perceived viscosity V (%)

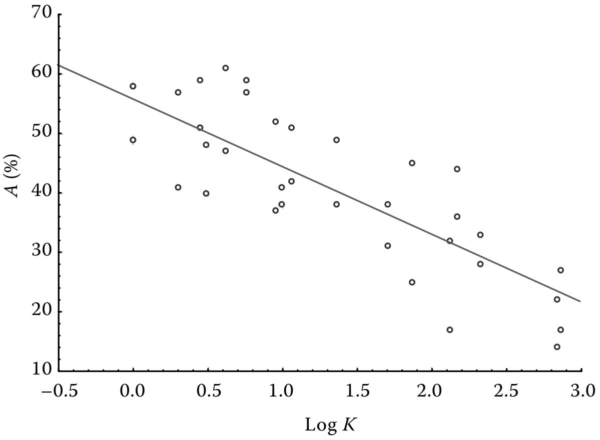

Figure 2. Relation between the sensory acidity A (%) and the kinematic viscosity K (mm^2/s)

CONCLUSIONS

The effect of thickening agents on the perceived intensity of acid taste was small but at higher concentrations the effect was statistically significant. The viscosity was inversely proportional to the acidity at the viscosity levels higher than 10 mm^2/s. A liquid of high viscosity thus possess lower acidity than aqueous or low-viscosity solutions. No significant differences were found between the effects of different thickening agents. Suppression of the acidity would thus occur at higher viscosities only, but not in the viscosity range common in soft beverages.

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