Evaluation of Physicochemical and Sensory Properties of Ethanol Blended with Pear Nectar

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Abstract

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Ten trained panelists evaluated the perceived density as well as the physical and perceived viscosities of the product obtained by blending ethanol with pear nectar. There was a link between the concentrations of ethanol in pure vodka and in its blend with the nectar, and the perceived sensory viscosity and the drink density. There was a very good (R^2 = 0.9442) and poor (R^2 = 0.6464) correlation, respectively, between the experimentally found density and viscosity and the perceived viscosity of aqueous ethanol. These properties of aqueous ethanol and alcohol pear drinks correlated very well (R^2 = 0.9430 and 0.9774) with one another. 50% ethanol with the nectar had a density similar to that of aqueous ethanol solution taken as the standard. The admixture of the pear nectar increased the sensory sensitivity of the viscosity measurements of these solutions. The correlation between the perceived and physical viscosities could be used as a guide for the sensory and qualitative control of vodkas.

Keywords: alcohol; nectar; model alcohol; perceived density; perceived viscosity

Mouthfeel and texture are the major determinants for consumers acceptance of and preference for foods and beverages (Szczesniak 1979, 1990; Noble *et al.* 1987). Viscosity, density, and surface tension are the essential rheological properties of liquids influencing such operations as pumping, filtration, clarification, and others. Viscosity, density, and surface tension are also important elements of the quality characteristics, which affect the mouthfeel of liquid food products. They also modify other sensory properties like saltiness, sweetness, bitterness, flavour, and astringency (Christensen 1980a; Smith *et al.* 1996; Hollowood *et al.* 2002; Yanniotis *et al.* 2007).

Food texture was first defined as mingled experience derived from the sensations of the skin in the mouth after ingestion of a food or beverage, as it relates to density, viscosity, surface tension, and other physical properties of the material being sampled (\nurgel *et al.* 2004). It was also defined as a response of the tactile senses to physical stimuli

that results from the contact between some parts of the body and the food (Bourne 1975). Texture is related mostly to solid and semi-solid foods, whereas the mouthfeel deals with the tactile (feel) properties perceived at the time at which solid and semi-solid or liquid foods or beverages are placed in the mouth and kept there until they are swallowed (Christensen 1980b; Dickie & Kokini 1983; Burns & Noble 1985; Forde & Delahunty 2002).

It is important to understand how and where the interactions are generated as they have impacts on the flavour perception and the key sensory profile of the products. They are physical interactions between the components in the food or beverage matrix influencing the volatiles release (Da Porto *et al.* 2006) and/or viscosity (Walker & Prescott 2000), and multi-modal interactions resulting from the cognitive or psychological integration of the anatomically independent sensory systems.

Physical viscosity, density, and yield stress have also been used to give a more comprehensive profile

of the rheological properties of fluids (Cichero *et al.* 2000). While ethanol concentration was found to be highly correlated with the perceived intensity and physical measurements of viscosity and density, the perceived viscosity (PV) and perceived density (PD) maxima were best described by square and cubic models, respectively.

Ethanol is commonly utilised in composing various beverages and flavoured vodkas. An increased attention has been recently paid to flavoured beverages. For instance, in 2008, Finlandia Vodka company noted a 30% increase in the sale of flavoured vodkas.

Flavoured vodkas contain herb extracts and essences, plant distillates, fruits and their juices, and volatile aromas. In this study, the effect of the compounding ethanol with pear nectar upon physicochemical and sensory properties of the resulting beverage is investigated.

MATERIAL AND METHODS

Materials. Rectified ethanol, 96% (POCH, Gliwice, Poland) and preservative, colorant, and sugar free pear nectar manufactured by Gerber (Nestle Nutrition, Kalisz, Poland). According to the manufacturer, its composition was 0.3 g protein, 10.6 g carbohydrates, 0.2 g lipids, 0.04 g fibre, < 0.01 g sodium, min. 25 mg C vitamin in 100 g of the nectar.

Ethanol was diluted with distilled water providing solutions containing 10, 20, 30, 40, 50, 60, and 70 vol. % ethanol, and with pear nectar to obtain solutions with the same ethanol concentrations.

Physical density of the solutions was determined pycnometrically at 20°C and the physical viscosity (kinematic) of the solutions was determined at the same temperature with a Cannon-Fenske capillary viscometer (No. 300) (Cannon Instrument Co., State College, USA). All measurements were done in 6 replications. Physical viscosity was calculated according to the following formula:

$$\eta = \frac{t \times \delta \times \eta_0}{t_0 \times \delta_0}$$

where:

η – solution viscosity (mPa·s)
η_0 – distilled water viscosity (mPa·s)
δ – solution density (g/ml)
δ_0 – distilled water density (g/ml)
t – time of solution flow (s)
t_0 – time of distilled water flow (s)

Aqueous 10–70 vol. % solutions of the nectar were taken as standards.

Sensory evaluation of the ethanol-pear nectar blends

Panel training. Ten panelists aged 24–55 received the information about 15 cm scale of the both density and viscosity values perceived together with marked boarder and median values of density estimated with the use of standard solutions as shown in Table 1.

Moreover, the panelist were trained in the procedures of density and viscosity solutions evaluation according to Pickering *et al.* (1998) in sessions of 1 h a day lasting 3 weeks. In the training of the perceived density estimation, they used samples of condensed milk and distilled water as models of very high and very low density liquids, respectively. In the training of the estimation of the perceived viscosity, they used tomato juice and distilled water as very viscous and very thin liquids, respectively. The perceived density was defined as feeling the weight of samples of constant volume (15 ml) loaded into the mouth, and the perceived viscosity was estimated from the flow of that sample between the cheeks. The estimation

Table 1. Standard solutions of carboxymethyl cellulose (CMC) used in construction of perceived density and viscosity

Property	Standard	Position on line scale (cm)
Viscosity minimum	distilled water	0
Median viscosity	0.3 g/l CMC	9.6
Viscosity maximum	2 g/l CMC	15
Density minimum	distilled water	0
Median density	0.3 g/l CMC	8.87
Density maximum	2 g/l CMC	15

Table 2. Form of sensory evaluation of the ethanol (A), nectar mixes – solutions containing 50% nectar (B), 10% nectar (C), and 20% nectar (D)

Samples compared to standard	A B	A C	A D	Preferences
Higher density				
Lower density				
Similar density				
Higher viscosity				
Lower viscosity				
Similar viscosity				

A – model alcohol for which, in the 15 point scales, density and viscosity were estimated for 6 and 5.66, respectively

of the perceived density was performed within the first 6 seconds after loading the sample into the mouth, and within 8 subsequent seconds the perceived viscosity was estimated.

Test procedure

Step 1. Samples of 7 aqueous ethanol solutions and 7 mixes of ethanol with the nectar of the concentrations from 10 to 70% vol. in each series, all at 20°C, were evaluated by the panelists in two repetitions following fully fortuitous sequence of the samples taken for evaluation. After each test on an unknown sample other than distilled water, the panelists washed their mouths with distilled water. One hour breaks were kept between the series of estimations. The panelists had to fit their impression to the 15 point evaluation scale. The results were placed in the evaluation form.

Step 2. The values of 5.66 and 6 on the scale of the perceived viscosity and density, respectively, were ascribed to 50% ethanol (A) of the highest

experimental viscosity at 20°C. The values of the perceived density and viscosity of the model alcohol were elucidated experimentally (Figure 1). That solution was selected as the standard. Then, the parameters of AM (model alcohol) were compared with those perceived in the case of the ethanol–nectar mixtures. Additionally, the panelists had to point to the mix they preferred. The results of that study are collected in Table 2.

Data analysis. *t*-Student test was used for the statistical evaluation of the correlation coefficients and regressions. The least square method was used for the parameters of linear equations. Statistica 6.0 software (StatSoft Poland, Kraków, Poland) was employed.

RESULTS AND DISCUSSION

The study showed that the perceived and experimental densities linearly ($R^2 = 0.9442$) decreased with the increase in ethanol concentration (Figure 1a). In a similar study performed for the per-
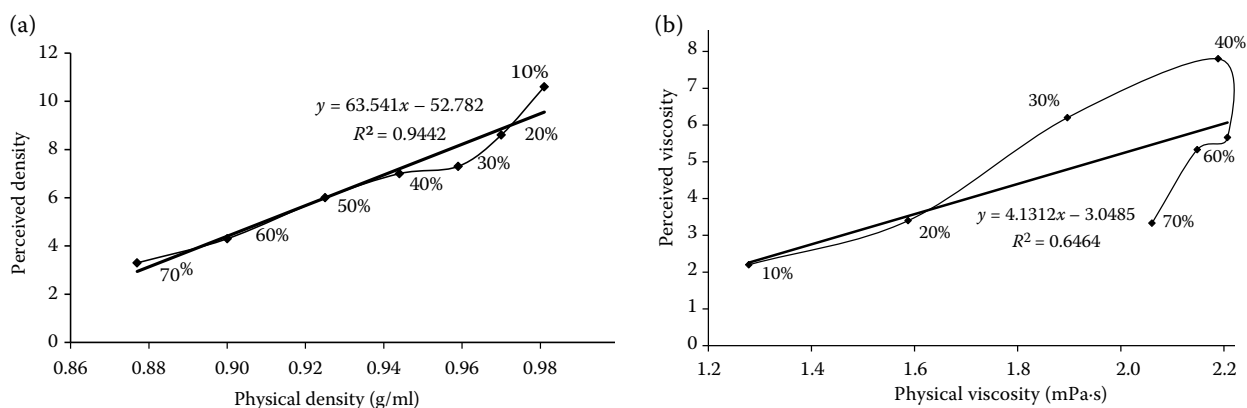

Figure 1. Perceived density vs. experimental density (a) and perceived viscosity vs. physical viscosity (b) relationship for aqueous ethanol of varying concentration (measurements taken at 20°C)
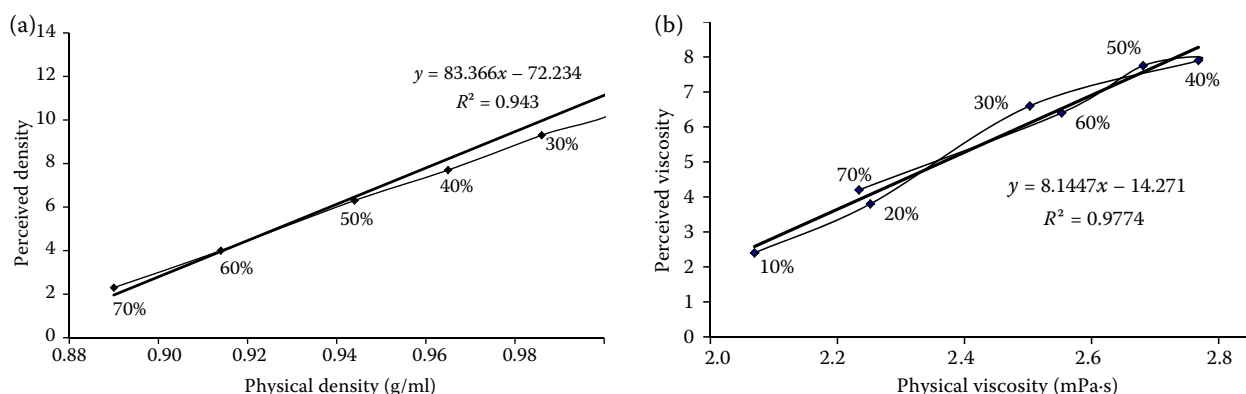
Figure 2. Perceived density vs. experimental density (a) and perceived viscosity vs. physical viscosity (b) relationship for ethanol–pear nectar beverage of varying concentration (measurements taken at 20°C)

ceived and experimental viscosities, it was found that initially, up to the 40% ethanol concentration, the correlation was excellent and these parameters reached maximum. In more concentrated solutions, the perceived viscosity decreased (Figure 1b). The overall concentration was described by $R^2 = 0.6464$ indicating that the sense of the panelists taste was sensitive enough to distinguish between the relatively low changes in ethanol concentration.

As the concentration of ethanol in the beverage with pear nectar increased, the perceived and experimental densities decreased while the relationship between the sensory and physico-chemically estimated parameters (Figure 2a) was good ($R^2 = 0.9430$) at $P < 0.001$. The regressions for ethanol solutions with the nectar were more slopy than those for aqueous ethanol, tga = 83.36 and 63.54, respectively, which means that the nectar better controlled the perceived parameters (Figures 1a and 2a). The results of the sensory analysis of viscosity (Figure 2b) show that the perceived and experimental viscosities excellently correlated with each other ($R^2 = 0.9774$) at $P < 0.001$. Although in this case there was also a decrease in viscosity at the ethanol concentration above 40% vol. ethanol,

the correlation was considerably better than that for less viscous and less dense samples of aqueous ethanol. The steeper slope of regression for alcoholised nectar than that for aqueous ethanol, tga = 8.15 and 4.13, respectively, informs that the perceived viscosity also strongly depended on the nectar component (Figures 1b and 2b). Thus, the nectar increased the sensory sensitivity of the viscosity measurements in these solutions.

Nurgel and Pickering (2005) observed strong positive correlations between the physical and perceived viscosities of aqueous 10.8–12% (v/v) ethanol. Positive or weak, moderate or strong correlations were observed between the physical density and PD for the 10, 8, and 12% ethanol solutions, respectively. The authors suggested that such correlations could be used as a guide for the sensory and quality control of ice wine.

Pickering et al. (1998) also provided evidence that ethanol improves the taste of dealcoholised white table wine supplemented with 0, 3, 7, 10, 12, and 14% v/v ethanol. They found that, with the increase in ethanol concentration of up to14%, the perceived density of that wine also increased, whereas the maximum perceived viscosity was

Table 3. Comparison of physical and perceived parameters and preferences of standard drink with selected ethanol–pear nectar beverages taken at 2°C

Sample	Sample				Preference
	A (AM) (50%) EOH	B 50% EOH + nectar	C 10% EOH + nectar	D 20 % EOH + nectar	
Physical density (g/ml)	0.925	0.944	1.004	1.004	D
Perceived density	6.45	6.5	6.8	6.85	(80% panelists)
Physical viscosity (mPa·s)	2.207	2.681	2.069	2.251	D
Perceived viscosity	5.66	7.80	4.50	6.00	(80% panelists)

observed in wine with 10% v/v ethanol. The insight in details of these results rationalised the statement that senses are more sensitive to viscosity than to density.

The comparison of the perceived density of standard ethanol (A) and those of selected mixes with pear nectar suggests that 50% mix had a similar perceived density as A. The mixes with lower contents (10 and 20%) or what had a higher perceived viscosity reaching its maximum in 20% mix, and this composition received the highest appreciation from the panelists (Table 3).

The comparison of the perceived viscosity of A with ethanol–pear nectar mixes pointed out to 20% mix as that of the perceived viscosity similar to that of A. The taste of that sample was preferred by the majority of panelists (Table 3).

In Yanniotis' *et al*. (2007) study, the alcohol content and dry extract were identified as the two factors that most influenced the viscosity of the wine, while glycerol had a negligible contribution to it due to its low concentration. Szczesniak (2002) concluded that there was an excellent correlation between the instrumental and sensory ratings for semi-fluid foods. Folkenberg *et al*. (1999) also presented a high positive correlation between the sensory and experimental viscosities of instant hot cocoa drinks. Richardson *et al*. (1989) obtained similar results for gel solution systems, reporting that the thickness of these solutions was related to the rotational viscosity measured at 50/seconds.

Vodkas and common European drinks contain 35–50% ethanol. The most common vodkas contain about 40 vol. % ethanol. According to the mouthfeel theory, the perceiving taste is associated with the molecular structure of the drinks. The more ordered is their structure, the more appreciated are the sensory impressions. 45% ethanol has the most ordered structure among alcohol–water solutions in the concentration range from 0% to 96% ethanol (Mazurkiewicz *et al*. 2007).

CONCLUSION

A link was found between the concentrations of ethanol in pure vodka and in its blends with the nectar and the perceived sensory viscosity and density of the drink. The admixture of the pear nectar increased the sensory sensitivity of the viscosity measurements in these solutions. The correlation between the perceived and physical viscosities could be used as a guide for the sensory and qualitative control of vodkas.

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