SENSORY PROPERTIES AND CHEMICAL COMPOSITION OF CIDER DEPENDING ON APPLE VARIETY

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Abstract
Apple variety influence chemical composition and sensory properties of products obtained from apples. This paper reports the influence of apple varieties on the sensory properties of the cider evaluated by two differently trained panel groups. Juices of five varieties apples (‘Auksis’, ‘Lietuvas Pepins’, ‘DI-93-4-14’, ‘Remo’ and ‘Kerr’) were fermented with *Saccharomyces bayanis* EC-1118 (Lalvin, Canada). The sensory evaluation of samples was carried out with two panel groups – experts (experienced in the field of beverage technology and evaluation) and trained panellists (finished basic course of sensory evaluation). Experts identified flavours of cider, and evaluated intensity of sensory properties, namely, clarity, aroma (apple, fruit, yeast), taste (apple, yeast, sour, astringent, bitter) using line scale. Trained panellists evaluated the samples only using line scale. Four descriptors were significant for characterization of differences in ciders from various variety apples, namely, sour taste, apple taste, apple aroma and clarity. The research suggests that, varieties with more intense apple and fruit aroma, apple taste and additionally with astringent and bitter taste notes are preferable. Taking into account these results, higher evaluations for cider ‘DI-93-4-14’ were observed, followed by ‘Remo’ and ‘Kerr’.
Key words: variety, cider, sensory properties, fermentation.

Introduction

Apple juice is the raw material of different fermented drinks, like apple wine and cider. The fermentation of apple must is a complex process involving several biochemical reactions. Overall quality of cider is influenced by many factors, namely, apple variety, yeasts strains, fermentation conditions, the production process and aging treatments (Hidalgo et al., 2004; Martınez-Rodrıguez and Polo, 2003; Beech, 1993). Cider flavour is composed by a wide variety of compounds with different aromatic properties. Moreover, the main cider aroma holds a close relationship with the type and concentration of aromatic compounds derived from apples (varietal flavour), other compounds are produced by yeasts and bacteria during alcoholic and malolactic fermentation (fermentative flavour) and compounds that appear during the ageing process (post-fermentative flavor) (Boulton et al., 1995). The esters and alcohols which are the products of fatty acid metabolization are the major groups in the apple juice. Esters associated with ‘fruity’ attributes, account up to 80–98% (Lopez et al., 1998). Phenolics have been shown to be important in the appearance and taste of cider and have been implicated in the quality of the beverage; and the polyphenolic profile of apples and apple drinks is also influenced by several factors: variety, climate, maturity, storage, processing (Van der Sluis, 2001; Ruiz-Rodriguez, 2008; Lata, 2007). Phenolics are associated with bitterness, astringency, and colour stability, and some of them have been used for detecting adulterations in apple products and could be inhibitors for microbiological growth-avoiding process spoilages (Madrera et al., 2006). But last investigations show that, for example, manipulating pressing conditions of apple juice bitterness and astringency decreased much less than the concentrations of native polyphenols (Renard et al., 2011), whichthat bitterness is the result of a more complex process. Not all ciders are made from ‘true’ cider apples. Many modern ciders have a high proportion of dessert and culinary apple varieties (Lea, 1995). In this work, special attention is drawn to the use of culinary apples for cider production. The apple variety ‘Auksis’ is the most popular commercially grown variety in Latvia. The apple varieties ‘Lietuvas Pepins’ and ‘Remo’ are used as culinary apple for juice production. The apple variety ‘DI-93-4-14’ is a new perspective apple variety for Latvian growers suitable for juice and wine production. Scrab apple variety ‘Kerr’ is grown in small areas on the Latvian farms, it is characterized by a clear, fragrant juice with considerable tannins contents, suitable for cider. Sensory properties are some of the most important factors on consumer liking and preference; thus it is very important to determine factors affecting the product attributes, acceptance and preference especially for foods (Dos et al., 2005; Medeiros de Melo et al., 2009). Sensory descriptive analysis is a primary tool of food scientists, which involves the evaluation of both the qualitative and quantitative sensory characteristics of products (Meilgaard et al., 1999). For evaluation of cider sensory properties, Williams (1975) developed 12 classes of descriptors that characterise the main typical flavours.

The aim of current research was to assess sensory properties of cider depending on apple variety evaluated by two differently trained panel groups.

Materials and Methods

Raw materials

Five apple varieties – ‘Auksis’ (A), ‘Lietuvas Pepins’ (LP), ‘DI-93-4-14’ (DI), ‘Remo’ (R), and ‘Kerr’ (K) –grown in the Latvia State Institute of Fruit Growing and harvested in September and October 2010 were used In the research. Juice was obtained by mechanical press Voran Basket Press 60K (Voran Maschinen GmbH, Austria). For stabilization of juice before fermentation, ‘Tannisol’ (Enartis, Italy) was added. Tannisol capsules consist of potassium metabisulphite (added amount to the juice – 9.5 g 100 L^{-1}), ascorbic acid (0.3 g 100 L^{-1}), and tannin (0.2 g 100 L^{-1}). Sulphites have various permitted uses, their primary function is that of a preservative and an antioxidant to prevent or reduce spoilage (Fazio and Warner, 1990), and they help to stabilize colour of the product and inhibit discolouration, thereby improving the appearance and flavour of many foods during preparation, storage and distribution (Adams, 1997).

Fermentation conditions

Fermentation was performed using commercial yeast *Saccharomyces bayanis* EC-1118 (Lalvin, Lallemand Inc., Canada) that is recommended for all types of wines, including sparkling, and cider. Fermentation was carried out at 16±1 °C for 28 days. The apple juice was fermented in a glass bottles (for each cider type n=5) with a volume of 750 ml. For analysis, the average juice samples were combined from the five bottles in equal proportions.

Sensory analysis

Sensory evaluation of fermented apple juices was carried out with two panels – experts (9 women and 2 men, aged 21–51) and trained panellists (31 women and 5 men, aged 21–58). Experts were specialists in the field of beverage technology and experienced in sensory analysis of beverages. Trained panellists had studied the basics of sensory evaluation methods and were experienced in several sensory panels. This group included students and staff of the Faculty of Food Technology.

Two methods of sensory analysis were used:

1) identification of cider flavour using characteristic descriptors divided in 12 classes (Table 1) developed by Williams (1975) – experts;
2) line scale (ISO 4121:2003) for measuring intensity of sensory properties (clarity, aroma (apple, fruit yeast), taste (apple, yeast, sour, astringent, bitter)) – experts and trained panellists.

Table 1

Characterization of cider flavours (Williams, 1975)

Classes	General characterization	Characterization of subclasses
1	Sour, acidic	Acidic, apple (sharp) acid, vinegar, lactic (soft) acid, citrus sour
2	Aromatic, fragrant, fruity, floral	Alcoholic (fusel), solvent-like (plastics, can-liner, acetone), estery (pear drops, apple-like with aniseed note, light fruity), fruity (citrus fruit, banana, blackcurrant, melon, pear, forest fruit, culinary apple, bittersweet apple), acetaldehyde, floral (rose-like, perfume-like, geranium)
3	Spicy, nutty, grassy	Spicy (resinous, woody, spicy bittersweet), nutty (walnut, almond), grassy
4	Caramelised, toasted	Caramel (molasses, raisins), burnt (toasted, rubbery)
5	Chemical	Phenolic (tarry, carbolic, antiseptic, iodoform), plastic, oily (mineral oil, vegetable oil), indole
6	Soapy, fatty, diacetyl, rancid	Fatty acid (soapy, cheesy, rancid butter), butterscotch, rancid
7	Sulphury	Sulphury, sulphur dioxide, sulphidic (rotten egg, drains, autolysed, burnt rubber, shrimp-like, cooked vegetable, cooked cabbage), yeasty
8	Oxidised, stale, musty	Stale, catty, papery, leathery, sherry-like, mouldy (earthy, musty), biscuit
9	Sweet	Honey, artificial (saccharin), vanilla, syrup
10	Bitter	Bitter
11	Mouthfeel	Alkaline, metallic, astringent (drying), powdery, creamy, carbonation (flat, gassy), warming
12	Fullness	Body (watery, characterless, satiating, thick)

Table 2

Chemical and physical parameters of cider

Variety	LP	A	R	K	DI
Titratable acidity, g 100 g^{-1}	0.88 ± 0.01	0.53 ± 0.01	1.01 ± 0.02	1.03 ± 0.02	1.10 ± 0.01
Total phenol content, mg 100 g^{-1} (Riekstina-Dolge et al., 2011)	67.01 ± 1.19	52.76 ± 0.9	45.23 ± 0.47	92.32 ± 0.92	54.01 ± 0.34
Soluble solids, g L^{-1}	0.77±0.02	0.51±0.03	1.03±0.02	1.28±0.05	1.28±0.04
Ethanol content, % vol.	5.07 ± 0.05	5.11 ± 0.09	5.10 ± 0.10	4.81 ± 0.13	4.99 ± 0.08

Chemical analysis

The total phenolic concentration was determined spectrophotometrically according to the Folin-Ciocalteu colometric method. Fermented apple juice was diluted with ethanol/acetic acid solution (1:20 v/v). Ethanol/acetic acid solution was prepared using acetic acid water solution (2.5%) and ethanol (98% vol.) in ratio 10:90 (v/v). A total of 0.5 ml of aliquot was mixed with 0.25 ml of Folin-Ciocalteu reagents. After 3 min 1 ml of 20% Na_2CO_3 and 3.25 ml of distilled water were added. Samples were heated for 10 min at 70 °C and kept for 30 min at 18 ±2 °C temperature. The absorbance was measured at 765 nm using the spectrophotometer JENWAY 6300. Total phenols were expressed as gallic acid equivalents (mg L^{-1}). Each determination was performed in triplicate and results are expressed as mean ± SD. Titratable acidity was determined according to standard (LVS EN 12147:2001) procedure. Ethanol and soluble solids were separated using distillation procedure, and analysed gravimetrically – distillate for ethanol content and residues for soluble solids determination.

Statistical analysis

Analysis of variance was performed by ANOVA procedure, and p<0.05 was considered as statistically significant. Linear correlation analysis was performed with the software SPSS 17.00 for Windows.

Results and Discussions

Chemical and physical parameters of cider

Sensory perceptions are due to the physicochemical composition of ciders. Quality parameters of the analysed samples are given in Table 2. Titratable acidity of the samples ranged from 0.53 to 1.10 g 100g^{-1}

Table 3

Characterization of cider flavours by experts

Classes	General characterization	Characterization of subclasses	Samples				
			LP	K	A	DI	R
1	Sour, acidic	apple (sharp) acid	+	+	+	+	+
		vinegar	+	+	-	+	+
		lactic (soft) acid	-	-	+	+	-
		citrus sour	+	-	+	+	+
2	Aromatic, fragrant, fruity, floral	alcoholic (wine, fusel)	+	+	-	+	+
		esters (apple-like)	+	+	+	+	+
		citrus fruit	+	+	+	+	+
		pear	-	+	-	-	-
3	Spicy, nutty, grassy	woody	-	+	-	-	-
		nutty	+	-	-	+	-
		spicy	+	-	-	-	-
		grassy	-	+	-	-	-
4	Caramel	caramel	-	+	-	-	+
6	Soapy, fatty, diacetyl, rancid	fatty acid	-	+	-	-	-
10	Bitter	bitter	-	-	+	+	+
11	Mouthfeel	astringent	+	+	+	+	+
12	Fullness	body (characterless)	-	+	+	-	+
		body (satiating)	+	-	-	+	-

+ flavours identified in cider; - flavours not identified in cider

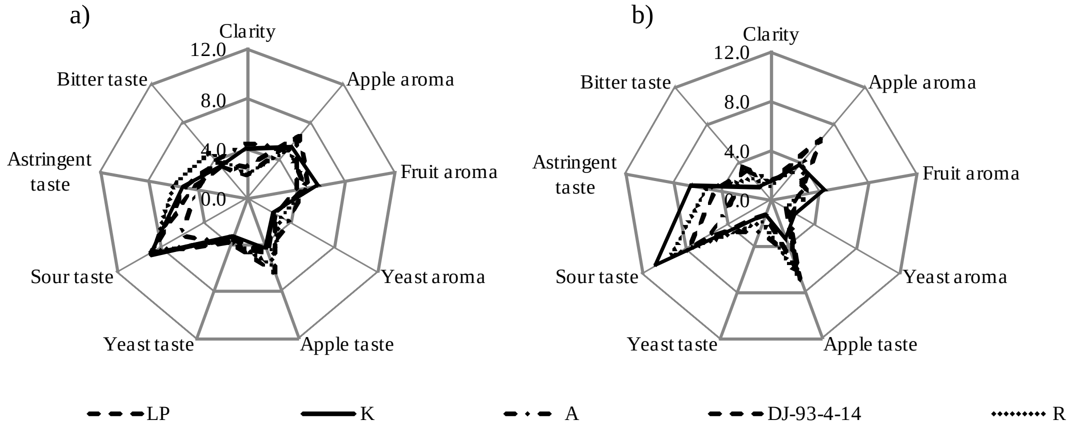

Figure 1. Evaluation of sensory properties of cider by trained panellist's (a) and experts (b).

– the highest content was determined in samples DI, K and R, whereas the lowest – in sample A. The content of total phenols varied depending on apple variety: the highest content was found in sample K (Table 2) but the lowest – in cider R. Variety 'K' belongs to scrab apple varieties and is suitable for cider fermentation (Riekstina-Dolge et al., 2011). Sanoner P. et al. (1999) also reported that polyphenol concentration is higher in cider varieties apples comparing to dessert apples.

Ethanol content of fermented drinks is critical for sensory evaluation. In mixtures without ethanol the fruity smell is strong; however, the intensity of the smell decreases with the increasing concentration of ethanol (Escudero et al., 2007). Also ethanol - induced palate warmth and perceived viscosity may indirectly affect both aroma and flavour perception (Delwiche, 2004). In all analysed samples, alcohol content did not differ significantly (Table 2), and it could not influence evaluation of other sensory properties.

Sensory evaluation of cider flavours

In analysed samples experts identified descriptors of eight classes of cider flavours: 1) sour, acidic; 2) aromatic, fragrant, fruity, floral; 3) spicy, nutty, grassy; 4) caramel; 5) soapy, fatty, diacetyl, rancid; 6) bitter; 7) mouthfeel and 8) fullness (Table 3).

In all samples, sharp acidity was found. Experts identified citrus notes in all samples but pear flavour only in cider K. In cider K also alcohol, wine and fusel notes, were observed.

In the identification of flavours, experts characterised the mouthfeel of fermented juices 'K', 'LP' and 'R' as astringent and dry. Mouthfeel of samples DI, K and LP was described as fullness, but R and A – as characterless.

Evaluation of the intensity of sensory properties

The evaluation of sensory properties by experts and trained panellists was analysed separately, and the results are presented in Fig.1.

According to ANOVA, the effect of apple variety was significant ($p<0.05$) for the following sensory properties: clarity, and apple and sour taste – for trained panellists, and apple aroma, and sour and apple taste – for experts.

Evaluation by trained panellists showed differences in juice clarity; significantly higher results for cider A were identified. It could be explained by pulp structure and maturity of apples. Maturity is an important factor influencing fruit quality (Streif, 1996); and if apples are harvested too early taste could be sour or starchy, and apples harvested too late may be soft and mealy. Starch also causes problems in juice clarification.

Experts and trained panellists evaluation showed that there is not significant differences ($p<0.05$) between samples in yeast taste intensity. Generally intensity of yeast taste for all fermented apple juices samples was not very intensive, and also yeasty flavours was not identified in analysed samples. According to experts and trained panellist assessment there is a significant difference ($p <0.05$) in the ciders sour taste intensity. The lowest intensity of sour taste in fermented juice A, whereas the higher intensity in fermented juices K, R, DI was determined. Correlation between titratable acidity and intensity of sour taste was performed. Trained panellists evaluation of sour taste intensity correlated very close ($r=0.94$), but experts evaluation correlated moderately ($r=0.74$) with titratable acidity. Assessment showed that more intense apple taste is in fermented juices R and DI, and also experts marked significantly higher intensity of apple aroma in those samples. Fruit aroma was not considered as significant properties for differentiation of ciders.

Bitterness and astringency contribute to the good taste of ciders and wines (Lule and Xia, 2005). There were not significant differences ($p>0.05$) in terms of bitterness and astringency between analysed samples. In cider bitterness and astringency are due to the polyphenols especially procyanidins which

Table 4

Correlation matrix among the descriptive terms of experts' estimate

	Clarity	Apple aroma	Fruit aroma	Yeast aroma	Apple taste	Yeast taste	Sour taste	Astringent taste	Bitter taste
Clarity	1	-	-	-	-	-	-	-	-
Apple aroma	0.064	1	-	-	-	-	-	-	-
Fruit aroma	0.068	0.308*	1	-	-	-	-	-	-
Yeast aroma	0.411**	0.092	0.163	1	-	-	-	-	-
Apple taste	-0.007	**0.526****	0.288*	0.233*	1	-	-	-	-
Yeast taste	0.236	0.046	0.272*	**0.642****	0.365*	1	-	-	-
Sour taste	0.025	0.057	0.064	0.099	0.116	-0.096	1	-	-
Astringent taste	0.158	0.092	-0.095	0.194	0.177	0.169	0.385**	1	-
Bitter taste	0.333**	0.041	0.056	0.438**	0.178	**0.510****	-0.069	0.240*	1

** Significant at p< 0.01

* Significant at p<0.05

are polymers of catechins (Noble, 2002). Correlation analyses between total phenol content and intensity of two sensory properties (intensity of astringent and bitter taste) were performed. Experts evaluation of astringent taste intensity correlated moderately (r=0.59), but trained panellists evaluation has not correlation (r=0.06) with total phenol content. Experts and trained panellists evaluation of bitter taste intensity correlated moderately negative r= -0.56 and r= -0.76 with total phenol content. There is often an interaction (Vidal et al., 2004) with other constituents of the beverage: alcohol and polysaccharides reduce astringency while pH can increase it without changing the bitterness (Kallithraka et al., 1997).

Intensity of sensory properties between experts and trained panellists evaluation differed. Mainly trained panellist's marks were higher, especially for apple and fruit aroma.

Correlation between sensory properties

Correlation analysis was performed to determine interactions between different sensory properties. Correlation matrix among the descriptive terms of experts' estimate is presented in Table 4. The expert and trained panellists' evaluation showed moderate correlation between yeast taste and yeast aroma (r=0.543).

In cider, bitterness alteration is characterized for an unpleasant bitter taste associated with the presence of acrolein combined to polyphenols (Sanchez et al., 2010). Heterofermentative *lactobacilli*, and mainly *L. collinoides*, are involved in bitterness production via glycerol dehydratase pathway (Garai-Ibabe et al., 2008). Bitterness results from glycerol degradation in apple-derived products. This degradation is leading to the formation of 3-hydroxypropanal under the action of lactic bacteria present in apple juice. Due to its high instability, 3-hydroxypropanal is spontaneously transformed in acrolein by dehydration (Sauvageot et al., 2000). There is no data about how bitter taste could be influenced by yeast or its metabolites.

Evaluation of sensory properties made by trained panellists showed moderate correlation (p<0.01) only between yeast taste and yeast aroma (r=0.501).

Correlation between the intensity of sensory properties was moderate or weak, and it is not possible to find relationship between the different attributes.

Conslusions

This work is the first study on sensory descriptors of ciders produced from five apple varieties grown in Latvia. Variation in the sensory properties of ciders depending on the used apple variety is attributed to physicochemical composition. Four descriptors, namely, sour taste, apple taste, apple aroma, and clarity were significant for characterization of differences in ciders from various varieties of apples. For development of qualitative cider, varieties with more intense apple and fruit aroma, apple taste and additionally with astringent and bitter taste notes are preferable. Taking into account these results, higher evaluation for cider 'DI-93-4-14' was observed, followed by 'Remo' and 'Kerr'. Experts and trained panellists evaluated intensity of sensory properties differently, and for new product development it is necessary to analyse both – experts' and potential customer's evaluation.

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