

Effect of the alcohol content on sensory perception of the fruit spirits

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Abstract: Fruit spirits must have an aroma of the raw material, which is balanced by ethanol. Since many aroma compounds are more soluble in ethanol than in water, ethanol is the most important carrier of aroma compounds. The alcohol concentration seems to be crucial for the sensory profile of spirits. Alcohol content of 40% vol is the standard alcoholic strength of fruit spirits. Regulations specify a minimum alcohol content of 37.5% vol. However, ethanol reduction can result in change in sensory profile of spirits. The aim of this research is to determine whether lowering the alcohol content of spirits may make them less acceptable to customers. On this occasion, 5 pairs of fruit spirits were sensory tested: pear, plum, apple, raspberry, and grape spirits, each with a commercial and reduced alcohol concentration to 37.5% vol. The results showed that customers can recognize the difference in alcohol content of fruit spirits and dilution to lower alcohol content led to decreasing aroma for all tastes fruit spirits. However, typicality and intensity of fruit odour and the overall note of the spirits, were very similar perceived for Williams, plum and grape spirits whereas apple and raspberry spirits showed better characteristic at higher alcohol content.

Key words: fruit spirits, alcohol content, aroma, sensory perception

Učinek vsebnosti alkohola na senzorično zaznavanje žganih pijač

Izvleček: Čeprav sta voda in etanol glavni sestavini sadnih žganih pijač, ne določata njihove narave in zvrsti, niti njihove senzorične kakovosti. Vzrok za to je prisotnost številnih aromatskih sestavin. Sadne žgane pijače morajo imeti aromo njihovih izvirnih surovin, ki je uravnavana z etanolom. Glede na to, da je veliko aromatičnih sestavin bolj topnih v etanolu kot v vodi, je etanol najbolj pomemben nosilec aromatskih spojin. Koncentracija alkohola je odločilna za senzorični profil žganih pijač. Za konzumiranje je standardna alkoholna moč žganih sadnih pijač 40 volumskih odstotkov. Predpisi določajo minimalno vsebnost etanola kot 37,5 volumskih odstotkov, kar uporabljajo mnoge destilerije pri proizvodnji žganih pijač. Namen te raziskave je bil ugotoviti, če lahko takšno zmanjšanje v vsebnosti alkohola potencialno zmanjša sprejemljivost žganih pijač pri potrošnikih. V ta namen je bilo preiskanih 5 parov žganih sadnih pijač in sicer hruškovo, slivovo, jabolčno, malinovo in grozdno žganje, v vseh primerih s komercialno in na 37,5 % vol. zmanjšano koncentracijo alkohola. Rezultati so pokazali, da uživalci zaznavajo razliko v vsebnosti alkohola v žganih sadnih pijačah, ker razredčenje na manjšo vsebnost alkohola zmanjša aromo in okus vseh preiskanih žganih pijač. Kljub temu so značilen vonj, okus kot splošne značilnosti bili podobno zaznani pri žganju iz hrušk viljamovk, sliv in grozdja, med tem, ko sta žganji iz jabolka in malin imeli boljše lastnosti pri večjih vsebnostih alkohola.

Ključne besede: sadne žgane pijače, vsebnost alkohola, aroma, senzorično zaznavanje

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1 INTRODUCTION

Spirits are alcoholic beverages produced by three successive processes: fermentation, distillation and alternative ageing in wood barrel. During the production of fruit spirits, numerous volatile substances are produced. Fruits are the source of the so-called primary aroma of spirits, which are the components that give the beverage identity and uniqueness for a particular fruit species or variety (Januszek et al., 2020; Spaho et al., 2023). Most volatiles are produced during alcoholic fermentation (Stacner et al., 2023), creating a fermentative or secondary aroma of spirits. Distillation is a process that controls the alcohol concentration and the composition of volatile compounds in distillates. It is enabled by fraction cutting (Spaho et al., 2013; Xiang et al., 2020), thermal energy input and reflux rates (Heller & Einfalt, 2022), and is strongly influenced by the type and design of distillation apparatus used (Balcerek et al., 2017; Rodríguez-Solana et al., 2018; Hodel et al., 2021). During distillation, alcohol and water are the actual carriers of hundreds of volatile compounds contained in the initial fermented mash. The quantity and quality of these volatile compounds in the vapor depend on their boiling point, their better solubility in water or ethanol, and the variation of ethanol content during distillation. The ethanol is enhanced and refined during the distillation process. Balcerek et al. (2017) and Xiang et al. (2020) demonstrated that increasing the final alcohol concentration in the heart fraction resulted in lower amounts of main volatile components in the distillates. Wie et al. (2018) showed that ester species and amounts increased significantly with increasing alcohol concentration in the heart fraction, while acidity decreased. During distillation heart fraction separate from head and tail fractions because these fractions are responsible for negative aroma attributes. With head fraction the majority of acetaldehyde, ethyl acetate, acetone are removed. Those compounds give sharp and unpleasant flavour. The tail fraction contains, acetic acids and fusel oils, such as propyl, butyl and amyl alcohols and their isomers, that are associated with unpleasant aroma attributes (Bohn et al., 2022). The maximum alcohol content in the middle (heart) cut of fruit distillates after distillation might be 86% vol, although in practice it is usually around 65-75% vol, depending on the distillation apparatus used (Durr, 2010; Lukić et al., 2011; Esteban-Decloux, et al., 2021; Tian-Tian et al., 2022; Lončarić et al., 2022). After distillation is completed, the fresh high-proof distillate has to storage for a period of time to harmonize. The concentration of alcohol in the heart fraction is especially important for the aging process, since the extraction of wood components, the clarity of the distillates, and the volatile compounds strongly depend

on the alcohol content of the distillates (Róžański et al., 2020; Valcarcel-Munoz et al., 2022; Butron et al., 2023).

A spirit straight from the still is not palatable, so it must rest for at least three months. The fresh distillates have a high alcohol concentration, and the sharpness of the alcohol affects the sensory perception of the usual fruit aromas. They also contain a large number of aldehydes, even if they have been properly separated beforehand, which, due to their stale and pungent smell and taste, lead to an inharmonious, unripe overall impression. The aroma-determining esters, which mostly form during storage of the distillate, are also missing (Scholtzen, 1999).

Consequently, the distillate must be diluted until bottling. The greater the dilution of the alcohol with distilled or demineralized water, the fewer odour components a spirit has. Today, alcohol concentrations of 40 to 45% vol. are common. This is the alcohol content to which consumers are accustomed. However, the EU Regulation (No. 2019/787) for fruit and wine spirits stipulates a minimum alcohol content of 37.5% vol. These regulations allow distilleries to offer spirits with a lower alcohol content than usual. For the industry, this means an increase in sales value, as the addition of water to dilute spirits is commonly regarded as a means of stretching production volumes. If finished spirit is diluted from 40 to 37.5% alcohol by volume, this means that 6.7 litres of distilling water were added to 100 litres of 40% vol alcohol distillates. It means 6.7 more litres of beverages for the industry.

This is added value for industry, but the question is: Is it acceptable to consumer? Do consumers perceive the alcohol reduction in fruit spirits and do they welcome the sensory changes caused by this reduction? Currently, there is limited data on the effects of alcohol reduction on the perceived sensory quality of these spirits and their appeal to consumer. Therefore, this study examined the impact of alcohol reduction in fruit spirits on consumer' perceptions and potentially reduction of their acceptability of spirits with low alcohol content.

2 MATERIALS AND METHODS

2.1 MATERIALS

This study evaluates five spirits produced from pear Williams, plum, apple, raspberry, and grape spirits. The spirits were purchased from various producers on the market. With the exception of raspberry spirits, these spirits were selected for their distinct aroma and popularity among customer from the West Balkan (Mrvcic et al., 2021). Each original bottled spirit with declared alco-

hol content served as a control, and the corresponding sample was prepared by reducing the alcohol concentration to 37.5% vol. Table 1 shows the alcohol content of the samples.

2.2 METHODS

2.2.1 Sensory analysis

Sensory analysis was performed by a consumer panel. Consumer panel members were recruited through online and in-person surveys. After 72 people were surveyed, a group of 30 individuals was selected based on their past experience with consuming spirits. They claimed to be moderate drinkers who believed they understand the range of quality of spirits. The panel consisted of 80% men and 20% women between the ages of 20 and 60.

All samples were sensory analysed using three sensory tests: paired comparison difference test, paired preference test and descriptive test (Stone and Sidel, 2004). Sensory analysis was performed in two separate sessions. In the first session, assessors used the paired comparison difference test and the paired preference test, and in the second session, the descriptive test.

The two coded products of each fruit spirit (control and reduced alc. sample) are served for the test of differences. In the directional test, the two presentation orders are AA, BB, AB, BA, where A is the control and B is the sample with reduced alcohol concentration. The paired samples are served simultaneously, and the individual is asked if “there is a difference.” Each assessor received a set of five pairs of samples (Fig. 1). They have taken a break between evaluation of each single paired. The order of the spirit series was randomised. The assessors were asked if “there is a difference”. If they notice a difference, they must choose more desired (preferred) samples.

After a one-hour break, the assessors evaluate the samples by a descriptive test. Prior to the analysis, the assessors received a brief training in the evaluation of spirits as well as insight into the sensory attributes of spirits.

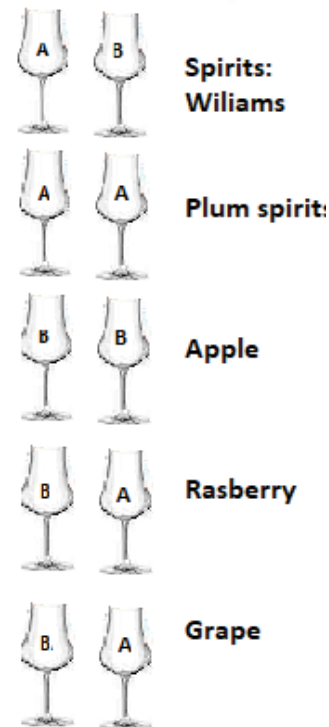


Figure 1: Series of five pairs of spirit samples that served to assessor, where A is the commercial alcohol content and B is the reduced alcohol content

The five sensory attributes were evaluated: typicality of odour and intensity of fruit odour, aroma, mouthfeel and overall note. Typicality of odour and intensity of fruit odour were evaluated by orthonasal while the aroma and mouthfeel were evaluated by retronasal. The overall sensation was evaluated as general impression of the spirit quality. Each sensory attribute was evaluated using a 5-point intensity scale (1-very weak, 5-very strong).

2.2.2 Statistical analysis

Analysis of paired comparison difference test based on the binominal distribution of answers. The binomial

Table 1: Alcohol content of commercial fruit spirits and their reduced value

Spirits from	Declared alcohol content in %vol	Reduced alcohol content in %vol
Williams	40	37.5
Plum	42	37.5
Apple	40	37.5
Raspberry	43	37.5
Grape	43	37.5

test is used to determine the probability of selecting the correct answer. Based on the total number of traces, the number of correct choices is taken from the table of binomial numbers to determine significance at the 0.05 probability level (O' Mahony, 1986). The Chi-square test was used to test whether the testers showed a significant preference for one of the samples (Meyners, 2007). The mean scores for the sensory attributes of the spirits were tested with a t-test using the Microsoft Excel software program.

3 RESULTS AND DISCUSSION

The assessor evaluated each pair of spirits and asked, „Are the samples different?“ The paired condense responses for all samples tested are shown in Table 2.

Sensory analysis of all spirits revealed significant differences between commercial and reduced alcohol content (Table 2). The assessors found a significant difference in the alcohol content of the tested spirit samples. This means that the sensory perception of beverages is significantly influenced by the alcohol concentration. This was evident in all fruit species (varieties) tested in this experiment. Raspberry spirits had the fewest incorrect responses in the evaluation, possibly due to the significant difference in alcohol content between the commercial and reduced versions of the spirits. Although the difference in alcohol content between the commercial (40 % vol) and light (37.5 % vol) versions of apple spirits was not as great, most incorrect responses were observed. However, the distribution of responses shows that respondents perceived a difference between apple spirits with high and reduced alcohol content.

In the statistical analysis of the preference test, only the responses of the assessors who correctly identified the differences were considered. The results of the preference test are shown in Figure 2.

Regarding the preference test, many of the assessors indicated that they preferred the beverages with higher alcohol content. However, a statistically significant difference is observed between pairs of the commercial and light versions of Williams pear, apple, and raspberry

spirits. Although more assessors indicated that a stronger sample of grape and plum spirits was more acceptable to them, there was no statistically significant difference in the distribution of responses between these pairs.

In a descriptive test, assessors were asked to rate the sensory attributes of each pair of spirits. Figure 3 shows the average scores for each sensory attribute of the spirits along with the results of the t-test.

Sensory perception of fruit spirits has been shown to be influenced by ethanol concentration, consistent with the findings of Ickes and Cadwallader (2017; 2018).

Spirits with higher alcohol content were mostly evaluated favourably by the assessors compared to their “light” versions. According to average ratings, Williams pear spirits with 40 % vol were rated significantly better in aroma than Williams pear spirits with 37.5 % vol. All other sensory attributes of Williams pear spirits were rated about the same. The difference in alcohol content was not sufficient to clearly distinguish all individual sensory properties except aroma. Nikičević (2005) states that a higher alcohol content is the ultimate for Williams pear spirits, as flavour and pleasure aroma are favoured at an alcohol content of more than 40 % vol.

Similar to Williams pear spirits, plum spirit with 42 % vol of alcohol was perceived significantly superior in aroma, while differences in smell attributes between stronger and lighter versions of spirits were not perceived. Mouthfeel (warming sensation) was also more intense for stronger plum spirits than for lighter version of plum spirits. This is not surprising, as ethanol causes a warming sensation in the mouth (Demiglio and Pickering, 2008; Longo et al., 2017; Ickes and Cadwallader, 2017).

However, mouthfeel is rated significantly better for apple spirits with lower alcohol concentration. Other studies have found that increasing the alcohol percentage causes a higher assessment of hotness or a burning mouthfeel experience (Le Berre et al., 2007; Jones et al 2008).

The dilution of the samples, with distilled water caused significant changes to the sensory profiles of apple and raspberry spirits. All sensory attributes of

Table 2: Number of responses of the assessors in the test of paired differences - commercial and reduced alcohol concentrations in the tested spirits where * indicates significance

Samples of spirits	Correctly noted difference	Incorrectly noted difference	Significance at $p < 0.05$
Williams pear	27	3	*
Plum	26	4	*
Apple	23	7	*
Raspberry	28	2	*
Grape	26	4	*

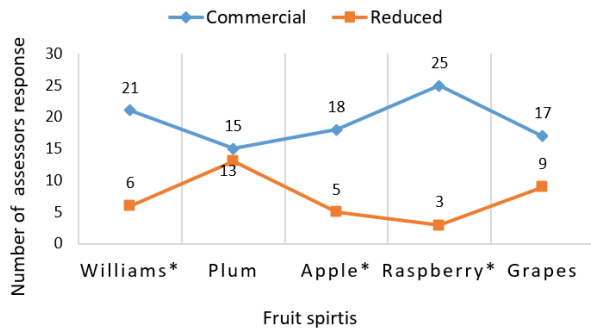


Figure 2: The results of the test preferences between fruit spirits with commercial alcohol concentration (higher % vol) and reduced alcohol concentration of alcohol (37.5 %vol), where * indicates significance at $p < 0.05$ for the *Chi-square* test

stronger apple and raspberry spirits are significantly better scored. In the study of Wei et al. (2018) it was shown that the concentration of esters, terpenes, and alkanes increased with increasing alcohol concentration. These authors also reported that spirits with higher content of alcohol were more fragrant than the spirits with lower alcohol. Also, Durr et al. (2010) pointed out that in finished spirits, some primary aroma compounds become more prominent at higher alcohol concentrations. The most important primary aroma compounds are terpenes, phenol compounds, aromatic ethyl esters of short-chain fatty, but also aldehyde compounds and alcohols (Spaho et al., 2021; Wang et al., 2022).

Because apple and raspberry spirits in this study, are significantly better scored in aroma and overall note in stronger versions of spirits it appears that these spirits are more characterized by primary aroma components where higher concentration of alcohol affects the release of apple and raspberry aromas. Many factors, as stated by Lyu et al. (2021), can influence the results of this sensory analysis: physical and chemical properties of volatile aroma components, low detection threshold, so that every dilution of spirits leads to a decrease in the aromatic value of aroma components, or physiological factors during tasting. More exact claims cannot be made unless the aromatic components in the tested spirits are identified and quantified analytically.

The influence of alcohol content was not as pronounced in distinguishing the sensory characteristics of grape-derived spirits. Grape spirit with 43 % vol alcohol was evaluated better in terms of aroma perception and less intense mouthfeel, while there were no differences between grape spirits with 43 and 37.5 % vol alcohol in the perception of other sensory properties. Although grape spirits with higher alcohol content (between 43 and 45 % vol) are frequently offered on the Balkan market, this study found that consumers did not perceive any

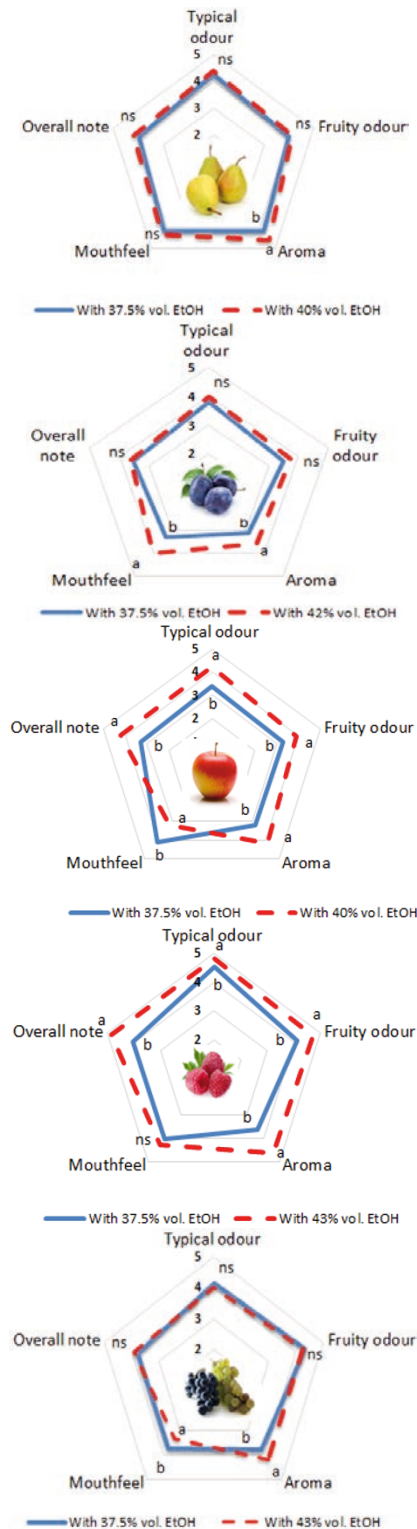


Figure 3: Sensory evaluation of Williams's pear, plum, apple, raspberry and grape spirits with higher alcohol content (40 % vol, 42 % vol, 40 % vol, 43 % vol and 43 % vol, respectively) and their „light“ version with 37.5 % vol of alcohol. The attributes with different letter are statistically different according to the results of t-test and $p < 0.05$; ns-no significance

changes in sensory quality when alcohol was diluted to 37.5 % vol. Our results are consistent with the findings of Scholten (1999), according to which the lowest possible alcohol content is preferred for spirits with sensitive, fine aromas, e.g., grape spirits, so that the fruit-typical odour and aroma can be better perceived.

4 CONCLUSIONS

According to the results of the paired comparison difference test, and the descriptive test, the consumers noticed the difference between the »strong and laight« version of spirits much more easily, although it was much more difficult to determine what this difference was manifested in. In other words, they know what they like but are unsure why. Consumer panels are susceptible to various biases, including response bias, and the sample size of the consumer panel used in this study may limit the generalizability of the results. Nonetheless, the outcomes of this study have repeatedly shown that consumers can detect a difference in the alcohol content of fruit spirits and, as a result, prefer Williams pear, apple, and raspberry spirit with alcohol content higher than 37.5 % vol.

The aroma of all fruit spirits with a higher alcohol content than 37.5% vol significantly better. In other sensory attributes our findings showed that the fruit spirits with commercial alcohol content and their dilutions version were more similar to one another. Reduction in ethanol concentration can affect consumers' perception of grape, plum and Williams pear spirits in terms of aroma and mouthfeel but in terms of fruit odour and intensity and overall note cannot. The apple and raspberry spirits, had better sensory quality in "stronger" versions of the spirits and these results indicate that it is better to bottle apple and raspberry spirits with high alcohol concentration.

The results of this study are a signal for the industry, as they show that customer preferences for alcohol content depend on the type of fruit spirit, as different fruit spirits have different requirements for alcohol content in bottled beverages.

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