Determination of Astringent Taste in Model Solutions and in Beverages

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Abstract

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The astringent taste is important for the sensory quality of beverages. Perception thresholds of two important astringent compounds – tannic acid and (+)-catechin were determined using two procedures. The concentration-intensity dependence was linear at low concentrations and up to medium intensities of the astringent taste if unstructured graphical scales were used, but the saturation threshold was soon attained in the case of tannic acid. Recording the results on printed forms gave similar results as using a touch-sensitive monitor. The optimum tasting was achieved at swallowing after degustation of 5 s. The duration of degustation increased the intensity. The astringent flavour was suppressed by sugar, but was not significantly influenced by ethanol, citric acid or quinine hydrochloride. Astringent substances were accurately perceived and rated in wine, tea infusion and orange drink, but the increase of astringency was smaller than in model solutions. The astringent taste was easily distinguished from the bitter taste.

Keywords: astringency; catechin; orange juice; tannic acid; tea brew; wine

The astringent taste belongs to important tastes in fruit and vegetables, and particularly, in beverages, such as green or black tea, coffee, orange juice or wine. The astringent taste is due to the presence of polyphenolic substances, and depends very much on the chemical structure (HASLAM & LILLEY 1988). They react either with saliva proteins or with specific proteins of taste receptors, producing thus a sensation of astringency (LEE & LAWLESS 1991). The terminology may be confusing, especially for naive consumers, as there exist several terms describing the sensation (CIVILLE & LAWLESS 1986) so that sensory assessors should be trained for correct evaluation of astringency in the presence of related tastes, such as dry, alum, puckery or roughing tastes (LEE & LAWLESS 1991). It is difficult to distinguish the bitterness and astringency in wine (FISHER & NOBLE 1994).

The astringent taste is typical of tea brews. Both catechins and epicatechins contribute to the astringent flavours (DING *et al.* 1992), but according to earlier results (OWUOR *et al.* 1986), theaflavins and thearubigins can also have minor effect. The astringent taste is due to phenolic substances (SINGLETON & NOBLE 1976), but polymerization products of catechins are particularly astringent (SINGLETON 1974). The astringency of black tea infusions was significantly correlated with total tannins (POKORNÝ *et al.* 1987). Monomeric catechins contributed to the overall astringency only when present at a large amount (ROBICHAUD & NOBLE 1990). Tannins increase the astringency, and thus improve the quality of beer (KRETSCHMER 1992). Astringency is a typical taste taint of most fruit juices.

In this study, we evaluated the effect of concentration and of taste interactions on the astringency both in model solutions and in beverages.

MATERIAL AND METHODS

Material: Tannic acid (Aldrich-Chemie, Steinheim, Germany), (+)-catechin (Sigma Chemical Co., St. Louis, MO, USA); citric acid, chemically pure (Lachema, Brno, CR); orange emulsion base No. 62105 (Aroco s.r.o., Prague, CR); sucrose, pure (Lachema, Brno, CR); red wine Frankovka (Mikulov, Moravia, CR), conforms with the Czech standard ČSN 56 7741 requirements; Abruzzi red wine (conforms with the current Czech legislation); model orange sirup prepared by mixing 94.5 g sucrose, 10.5 g orange emulsion base, 30 g citric acid and 42.0 g tap water; orange drink was prepared by diluting 123 g of the above orange sirup with 905 ml tap water.

Methods: The sensory analysis was performed following recommendations of the international standard (ISO 6658 – 1985: Sensory analysis – Methodology – General guidance) in a standard test room (ISO 8589 – 1988: Sensory analysis – General guidance for the design of test rooms), provided with 6 test booths. The sensory panel consisted of 25 selected and trained persons (ISO 8586-1 – 1993: Sensory analysis – General guidance for the selection, training and monitoring of assessors – Part 1. Selected assessors) with experience in the sensory rating of at least 6 months. Model samples (30 ml) were served in 50 ml dark brown glasses, samples of wine and orange beverage in colourless glasses.

The taste perception threshold was determined using the paired test (ISO 5495 – 1983: Sensory analysis – Paired comparison). The pairs consisted of a brown glass with distilled water and of another brown glass with the test solution of an astringent substance in distilled water, served in random order. Each concentration was served 40 times. From the set of 15 concentrations tested, the perception threshold was the lowest concentration that was found significantly different ($P = 0.95$) from water (MEILGAARD *et al.* 1987).

Another method for the determination of perception threshold was essentially the same as given below for the intensity rating; the perception threshold was equal to the lowest concentration significantly different from the control sample of distilled water ($P = 0.95$).

The intensity of astringent taste was rated using an unstructured graphical scale (ISO 4121 – 1983: Sensory analysis – Evaluation of food products by methods using scales), represented by an oriented straight line 100 mm long (0 mm = imperceptible; 100 mm = very strong). The assessors took 10–15 ml sample, left the draught in their mouths for 5 s (unless otherwise stated), moving it slowly by movements of the tongue, and rated the intensity of the astringent taste on swallowing the draught. The maximum of 4 samples were served at a session, with washing the oral cavity with tap water between the samples. The assessors rated using a printed form, unless the use of a touch sensitive monitor – Microtouch Studioworks 57 (LG Electronics, Inc., Seoul, Korea) is mentioned.

In agreement with the literature (MCBRIDE 1985) the graphical scale was considered as an interval scale (excepting 5 mm at the two ends), and mean values and standard deviations were calculated using the software Microsoft STATISTICA 3.0 ($P = 0.95$).

RESULTS AND DISCUSSION

Determination of Perception Thresholds: The perception threshold of tannic acid was studied in the concentration range of 0–0.4 g/l. Four concentrations and water were assayed at a session. According to the method using a graphical scale (standard deviation of the mean equal to 3 mm), average values of 12 determinations were calculated, and the concentration corresponding to the response of 12 mm was considered as the perception threshold (the mean value of distilled water was 3 mm). Mouth washing between the samples was used as it is necessary for exact evaluation, especially in the paired test in the case of solutions of very close concentrations (HOPPE 1984). The results are shown in Table 1. The perception thresholds of both tested substances were substantially lower if absolute rating and graphical scale were used. This method also better corresponds to the real application as consumers taste a single sample at a time, and they do not compare two samples.

Table 1. Perception thresholds of tannic acid and (+)-catechin

Test substance	Perception threshold	
	of tannic acid (g/l)	of catechin (g/l)
Paired test	0.05	0.30
Graphical scale	0.02	0.12

Effect of the Residence Time before Swallowing: Another important factor was the residence time of the draught in the oral cavity. Results of these experiments are shown in Table 2. If assessors could leave the samples in their mouths for any time they chose appropriate, no effect was observed. On the contrary, if each assessor had to taste the samples for each defined time interval tested before the swallowing, 7 min were found necessary to obtain the equilibrium and a constant response. The cause of this discrepancy was that the assessors more sensitive to the astringent taste kept the sample for shorter times in their mouths than in the first series of experiments.

Table 2. Effect of residence time in the mouth on the astringency at swallowing

Time before swallowing (s)	Residence time (mm of scale)	
	of compulsory	of arbitrary
2	32	56
5	41	65
7	60	59
10	60	53

Comparison of the Printed Form and the Touch Sensitive Monitor: Two methods of data recording were compared in an experiment using Abruzzi wine. The results are shown in Table 3. They give records obtained with a printed form and with a touch sensitive monitor. The re-

Table 3. Comparison between the intensity records using a printed form and a touch sensitive monitor

Sample code	Printed form (mm)	Sensitive monitor (mm)	Difference (mm)
A	64	60	–4
B	45	44	–1
C	72	63	–9
D	52	57	+5
E	50	41	–9
F	66	61	–5
G	56	51	–5
H	55	49	–6

sults do not substantially differ, even though the touch sensitive monitor gave slightly lower records. Therefore the use of the touch sensitive monitor, which was found moderately more difficult to use than the printed form, would be justified for time-intensity studies, but it is not necessary for simple scalar testing.

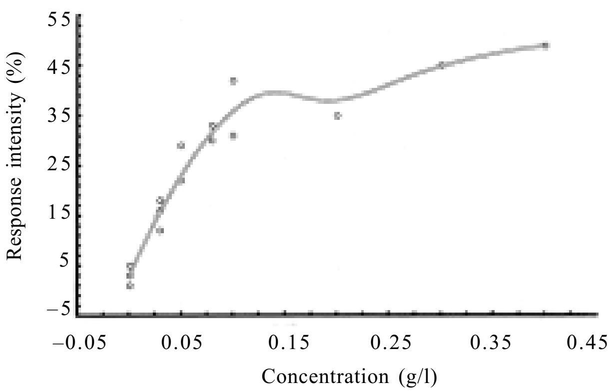
The Astringency-Concentration Relationship: The concentration-astringency relationships were determined in the concentration range of 0–0.4 g/l for tannic acid and 0–1.2 g/l for (+)-catechin, respectively. Not more than 4 samples were tasted at a session even though no sensory adaptation was observed in the case of astringent sensations (LEE & LAWLESS 1991). The lack of adaptation does not exclude the additive effect on tasting subsequently another astringent sample. The second sample seems more astringent than the first one (GUINARD *et al.* 1986b). Three subsequent ingestions of the same sample increased the astringency (GUINARD *et al.* 1986a). Therefore it is absolutely necessary to serve the samples in random order to avoid such an effect (ARNOLD 1983).

The result of tannic acid (Fig. 1) showed a nearly linear regression in the concentration range of 0–0.1 g/l, but rapidly approached the saturation threshold at higher concentrations, i. e. about five times higher than the threshold value. On the contrary, in the case of (+)-catechin, a linear concentration-astringency relationship was observed till 1.0 g/l, i.e. about 8 times the threshold value (Fig. 2).

Interactions of the Astringent Taste with other Tastes: Taste interactions are very important as they could affect the flavour of beverages. In these experiments (Table 4), tannic acid behaved entirely differently from catechin. In the presence of sucrose, the astringency of tannic acid was not significantly affected, but the astringency of catechin (which is more important in food materials) substantially decreased. The bitterness of quinine was also suppressed by sucrose (LAWLESS 1979). The suppression of a particular taste in a mixture was frequently observed in beverages and foods (LAWLESS 1986). An addition of sucrose suppressed the dryness and the bittering effect of tannic acid (LYMAN & GREEN 1990).

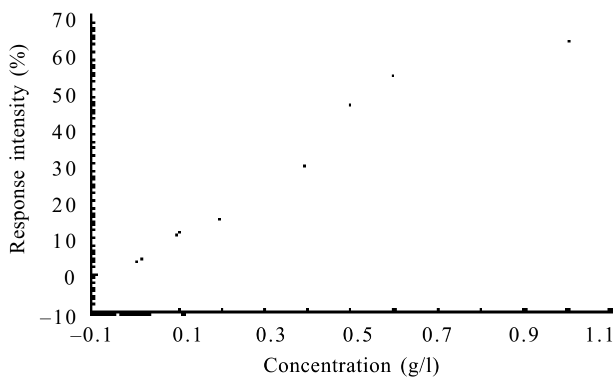
Table 4. Interactions of astringent substances with sucrose and citric acid

Interfering substance	Astringency of (mm of the scale)	
	tannic acid	catechin
Control	32	56
Sucrose (20 g/l)	30	26
Citric acid (0.5 g/l)	62	52



R – intensity of astringent taste (mm of the graphical scale); *C* – concentration (g/l)

Fig. 1. Effect of the concentration of tannic acid on the astringency of aqueous solution



R – intensity of astringent taste (mm of the graphical scale); *C* – concentration (g/l); the correlation coefficient r = 0.97 is significant (N = 10; P = 0.95)

Fig. 2. Effect of the concentration of (+)-catechin on the astringency of aqueous solution

Table 5. Effect of addition of tannic acid (0.18 g/l) and catechin (0.90 g/l) on the intensity of astringent taste in beverages

Beverage tested	Added astringent substance	Astringency of the control (mm)	Astringency of the test sample (mm)
Red wine	tannic acid	44	73
Red wine	catechin	43	73
Orange juice	tannic acid	42	62
Orange juice	catechin	43	51
Tea brew	tannic acid	46	58
Tea brew	catechin	45	56

An addition of citric acid substantially increased the astringency of tannic acid, but had no effect on the astringency of catechin (which is advantageous for the beverage industry). The only plausible explanation could be the difference in their chemical structure as tannic acid is a derivative of 1,2,3-trihydroxybenzene while catechin is a derivative of 1,2-dihydroxybenzene.

Effect of Catechin in Beverages: The effect of catechin addition to various beverages is shown in Table 5. It is evident that the addition increases the astringency, but the effect is smaller than in model solutions.

The effect of the two astringent substances was tested in red wine. Both tannic acid and catechin modified the flavour, but the effect should not be qualified as off-flavour. It should be better considered as modified taint (GRIFFITHS 1993). The effect of other taste substances on the astringent taste of red wine is shown in Table 6. Sucrose decreased the astringent sensation, ethanol slightly increased it, and quinine had no significant effect. In experience with wine, ethanol increased the bitterness caused by catechin (FISCHER & NOBLE 1994) but we could not confirm this observation in our experiments, probably because of the low concentration of catechin. Combinations of the three substances had an additive effect.

Table 6. Effect of different substances on the astringent taste of red wine

Sample tested	Frankovka wine (mm)	Abruzzi wine (mm)
Control wine	63	62
Wine + sucrose	42	44
Wine + ethanol	71	68
Wine + quinine	60	55
Wine + sucrose + ethanol	55	50
Wine + quinine + ethanol	65	61
Wine + sucrose + quinine	54	54
Wine + sucrose + quinine + ethanol	52	52

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Souhrn

Valentová H., Škrovánková S., Panovská Z., Pokorný J. (2001): **Hodnocení trpké chuti v modelových roztocích a nápojích.** Czech J. Food Sci., **19**: 196–200.

Trpká chuť má velký význam pro senzorickou jakost nápojů. V modelových roztocích byl zkoumán tanin a (+)-katechin. Dolní podnětový práh byl zjišťován párovým rozlišovacím testem a absolutně s použitím grafických nestrukturovaných stupnic Při použití druhé metody se jevila závislost intenzity trpkosti na koncentraci trpké látky od nejnižších po střední koncentrace jako lineární, ale u roztoků taninu se brzy dosáhlo prahu nasycení, kdežto u katechinu byl vztah lineární v celém sledovaném koncentračním intervalu. Párový test byl méně citlivý a poskytl odlišné prahové hodnoty. Při záznamu výsledků na předtištěný formulář se dosáhlo přibližně stejných hodnot jako při použití obrazovky citlivé na dotek. Optimální doba hodnocení byla při polykání po pětisekundové degustaci, ale s prodlužující se degustací rostla vnímaná intenzita trpkosti. Trpká chuť byla potlačována přítomností sacharosy, ale neměl na ni vliv ethanol, kyselina citronová ani hydrochlorid chininu. Hodnotitelé dokázali trpkou chuť dobře postřehnout a její intenzitu správně hodnotili v červeném víně, čajovém nálevu nebo v pomerančovém nápoji. Intenzita trpkosti stoupala s rostoucí koncentrací trpkých látek pomaleji než v modelových vodných roztocích. Trpkou chuť hodnotitelé bezpečně odlišili od chuti hořké.

Klíčová slova: čajový nálev; katechin; pomerančová šťáva; tanin; trpkost; víno

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