

The flavor and taste of cereal Chinese vinegars

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Abstract

A lexicon for describing Chinese cereal vinegars (CCVs) was developed using trained panels of tasters that defined and referenced 23 significant olfactory descriptors, in concert with taste and trigeminal sensation. The sensory analysis was performed on 27 samples, representative of the five well-known Chinese provinces producing vinegar: Shanxi, Jiangsu, Sichuan, Fujian and Tianjin. Several aromatic descriptors define the sensory lexicon, e.g.: licorice, chocolate, meat broth, toasted, walnut, yogurt, coffee; together with five basic tastes, such as acid, sweet, salty, umami and bitter; and four for trigeminal sensations, astringent, pungent, metallic, and piquant (spicy). This preliminary study will be useful to CCVs producers because this lexicon reliably differentiates and characterizes this kind of vinegar.

Introduction

China has a very long tradition in the production of grain vinegars.¹ Chinese vinegars differ for the type of cereals and legumes

used as raw material, for the production technology and the more or less extended aging.^{2,3} The most widespread and well established vinegars come from four districts and differ for the ingredients: Fujian (water, glutinous rice, red yeast rice, sugar, salt); Jiangsu (water, glutinous rice, bran, sugar, salt); Shanxi (sorghum, barley, bran, chaff, pea, salt, water); Sichuan (bran, wheat, rice, glutinous rice) and Tianjin (water, sorghum, millet, wheat, pea). The production technology has many aspects in common, but also few important differences. Among them, heat treatment or toasting (at least on part of the product) even in the presence of chaff; concentration in open jar or in special evaporation chambers (Shanxi aged vinegar and Zhenjing aromatic vinegar). Furthermore, in the past, in the region of Shanxi and Tianjin, vinegar was concentrated during the harsh winter, removing the ice crystals. All these differences in raw material and technologies suggest marked difference among vinegars, or between vinegars of the same type but otherwise aged. For a more complete and articulated discussion on the production technologies of cereal vinegars, refer to the literature.^{1,4,2}

The sensory analysis of vinegar is not easy for at least two reasons: the strong aggressiveness of acetic acid on the sensorial papillae⁵ and the absence of definition of the sensory attributes of vinegar.⁶ To overcome the first hurdle, it is necessary to set a tasting procedure to preserve the tasting abilities of the panelists, the literature on the topic is large and well documented.⁶⁻⁸

Regarding the sensory attributes, there is shared a general vocabulary to describe the sensory properties of vinegars and in particular for Jerez vinegar,⁹ but few data, in our knowledge, on cereal vinegars and all on Japanese ones.¹⁰ From the literature on wine vinegars, we can derive some characteristic and common indicators referring to vinegars.¹¹ The first is, without a doubt, the pungency, a more tactile feel and smell; other terms used frequently are: glue, alcoholic, vinous, raisins, woody, cloves, citrus, red fruits, vanilla, sweet aroma, bitter almond, medicine, apple, and coconut. Some attributes are decisively negative, such as old/leather, rancid, bacteria, cheese and sawdust/wood.^{5,8}

A shared vocabulary or lexicon is a necessary condition for proper sensory analysis of any food,^{12,13} because lexica are the common language for describing products. The purpose of a lexicon is four-fold: i) to collect a product frame of reference; ii) generate the terms; iii) review references and examples; iv) develop a final descriptor list. Numerous lexica have been developed for a variety of products such as: cheddar cheese;¹⁴ peanut; for handfeel properties;¹⁵ soymilks;¹⁶ floral honey;¹⁷ green tea.¹⁸ The purpose of the current study was to develop a comprehensive sensory lexicon for Chinese cereal vinegars, developing an appropriate sensory terminology.

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Key words: Cereal vinegar; Chinese vinegar; sensory analysis; flavor descriptors; sensory vocabulary.

Contributions: PG conceived and wrote the article; TB reviewed and coordinated the writing procedure; FL and GC elaborated the sensory data; TB, GC and FL organized and coordinated the sessions of sensory analysis; JW and FC handled the section about vinegar description.

Received for publication: 15 November 2016.

Revision received: 27 December 2016.

Accepted for publication: 10 January 2017.

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Acetic Acid Bacteria 2017; 6: 6370
doi:10.4081/aab.2017.6370

Materials and Methods

Samples

Shanxi Aged Vinegar Group Co. Ltd. provided 27 samples from the most popular areas of Chinese cereal vinegar. They have been chosen to represent the population of industrial vinegars available on the market. They also differ for age, acidity, sugar content and production technology. Table 1 shows the complete list of vinegars.

Sensory evaluation

Panel

Seventy trained Italian judges evaluated the samples of CCVs for lexicon development. Four panels from university, industry and cultural association were assembled. The panels consisted of 21 females and 49 males. The greatest part of the judges was qualified as tasters, only someone with specific vinegar tasting experiences. The diverse backgrounds of panelists were effective in generating a comprehensive initial language for comparison with the preliminary descriptor list. Nothing was told to judges about the CCVs (*e.g.*, origin and method of processing), in order to reduce any possible biases. The four tasting sessions included up to a maximum of 20 judges per session. Each member has never tasted the same sample twice, then not all the members have tasted all the samples. The tasting procedure was conducted on samples obscured with aluminum foil to avoid the influence of visual observation on the olfactory and taste perceptions. Vinegar samples of about 3 mL were served in small glasses. The glasses were closed with their lids and left at room temperature for at least 10 minutes. The judges were informed of the sensory techniques to assess aroma and flavor attributes according to.¹⁹

The judges evaluated each CCV individually: the aim of the sensory test was not to assess the intensity of each descriptor but to understand which descriptors were mainly perceived in CCV as a category of products. We provided the tasters with notebooks and we asked them to write down all the perceived descriptors, both the taste- and flavor-related ones. After the tasting, the panel leaders led a discussion to come to agreement on the descriptors present in the CCV sample. As the panel agreed on descriptors, they began to define and reference each of them. The panel was asked to be as specific as possible in identifying descriptors.

Results and Discussion

The first objective of the research was to identify all possible descriptors of the CCVs, regardless of the type and area of origin. For this purpose, the panel members were asked to describe the aromas and, later, taste samples. Each vinegar has been tasted by at least 20 judges. At the end of each tasting session, the panel leaders steered the discussion to standardize the meaning of terms used and, not secondarily, to group the terms based on a common meaning among the judges.

However, it should be considered that the panels were four and led by different leaders and with different judges. For this reason, it was not possible to get a vocabulary entirely shared by all the tasters in one single step. The results of this first aggregation are shown in Table 2, where it is possible to notice some significant similarities between some of the descriptors highlighted by the different panels. For example, different panel used respectively *Anise* and *Licorice* as a grouping descriptor of the same terms (Table 2). This is the reason why a second fine-tuning of descriptors was necessary, with few additional groupings. To do this, the panel leaders

and a group of trained judges made a further aggregation. This type of reduction is normal during the initial training section.²⁰ The taste of CCVs covered all the five well known sensations: sweet, bitter, acid, salty and umami; trigeminal sensations were spicy, pungent, astringent and metallic.

The smell of Chinese cereal vinegars

The most frequent terms grouped under a single descriptor according to their meaning are shown in Figure 1. The frequency, calculated by normalizing to 100, is the number of judges who have felt a particular descriptor in at least one of the vinegars of his sensorial session. Figure 1 shows distributions of the descriptors found in CCV. Whereas no judge has tasted more than nine CCVs samples, the very high relative frequencies can be taken as evidence of specific descriptors for CCVs.

The distribution histogram clearly shows that some descriptors are really frequent in CCVs, in particular chocolate, toasted, meat broth, licorice, walnut, yogurt and others. Nevertheless, they do not give any information about the different type of vinegars. In order to highlight olfactory differences between the diverse vinegars, the data were broken down and grouped by brand and/or origin (data not shown). The five vinegars coming from the Shanxi (samples A, B, C, D, E) showed different sensory profiles based on detection frequency. In particular, the greatest part of judges who tasted vinegar Donghu (sample A) have perceived walnut notes and meat broth as prevalent olfactory descriptors. Meiojee vinegar was characterized by a strong *walnut* together with *leather* and *caramel*. The C series (Zilin) has a strong scent of *meat broth*, *flour* and *walnut*; all the three flavors tend to be detected at a higher frequency in the more aged vinegars. An intense aroma of licorice was recognized in the D samples (Ninghua fu) and E (Shuita); the fragrance was perceived by 100% of the judges who have tasted the samples of the two oldest vinegars. Younger samples of the same vinegar also had the same aromas at a lower frequency and other smells like meat broth, smoked, fruit and glue. The three F samples (Boaning vinegar) have a strong smell of meat broth, yogurt and fruit, the last one decreases with the ageing. The three samples of Yongchun (G) aged vinegar are characterized by a smell of fruit, which decreases with the ageing, to leave more space to the odor of yogurt and glue. The Henshun vinegars (H) are well characterized by scent of meat broth that increases with the ageing. The oldest Tianli Dulu samples (I) have a strong smell of chocolate and toasted, while in the youngest yogurt, leather and smoked flavors prevail.

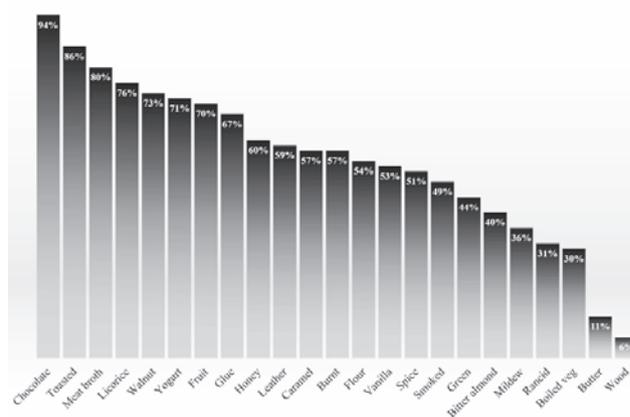


Figure 1. Percentage of judges who have felt at least one cereal Chinese vinegar with one or more of the descriptors listed.

Table 1. 样品信息 - Sample information.

地区	品牌	编号	年龄/类别	酸度	原料	
District	Brand	ID	Aging and/or Type	Acidity*	Raw Material	
山西	东湖		8年老陈醋 8 years		高粱、大麦、麸皮、谷糠、豌豆、食盐、水	
Shanxi	Donghu	A1	Shanxi Mature Vinegar (SMV)	8	Sorghum, barley, bran, chaff, pea, salt, water	
		A2		5年老陈醋 5 years SMV		8
		A3		3年老陈醋 3 years SMV		6
	美和居	B1	10年老陈醋 10 years SMV	7		
	Meiojee	B2	6年老陈醋 6 years SMV	6.5		
B3		3年老陈醋 3 years SMV	6			
		紫林	C1	8年老陈醋 8 years SMV	6.5	
	Zilin	C2	6年老陈醋 6 years SMV	6		
		C3	3年老陈醋 3 years SMV	4.5		
		宁化府	D1	10年老陈醋 10 years SMV	6	
	Ninghua Fu	D2	5年老陈醋 5 years SMV	6		
		D3	3年老陈醋 3 years SMV	5.5		
	水塔	E1	8年老陈醋 8 years SMV	6		
	Shuita	E2	5年老陈醋 5 years SMV	6		
		E3	3年老陈醋 3 years SMV	4.5		
四川		保宁	F1	5年老酿手工特制保宁醋 5 years Handmade Baoning vinegar (BV)	6	麸皮、小麦、大米、糯米、水
Sichuan	Baoning	F2	臻品保宁 Premium BV	6	Bran, wheat, rice, glutinous rice, water	
		F3	特级保宁 Superior BV	6		
福建	永春	G1	10年老陈醋 10 years Yongchun aged vinegar (YAV)	6.5	糯米、红曲、白糖、食盐、水	
Fujian	Yongchun		G2	8年老陈醋 8 years YAV	6.5	糯米、红曲、芝麻、水
			G3	3年老陈醋 3 years YAV	6.5	Glutinous rice, anka, sesame, water
江苏	恒顺	H1	6年老陈醋 6 years Zhenjiang aged aromatic vinegar (ZAAV)	6.4	糯米、麦麸、白砂糖、食盐、水	
Jiangsu	Henshun	H2	5年老陈醋 5 years ZAAV	5.5	Glutinous rice, bran, sugar, salt, water	
		H3	3年老陈醋 3 years ZAAV	5.5-6.0		
天津	天立独流	I1	8年老陈醋 8 years Diuliu Mature vinegar (DMV)	5	黄粟、高粱、小麦、豌豆、食盐、水	
Tianjin	Tianli Duliu	I2	5年老陈醋 5 years DMV	5	millet, sorghum, wheat, pea, salt, water	
		I3	3年老陈醋 3 years DMV	4	高粱、黄粟、小麦、豌豆、水	
					Sorghum, millet, wheat, pea, water	

*Expressed in g/100 mL of acetic acid.

In general, the tasted vinegars showed a complex aroma, but with one or few dominant odors that make them recognizable even to tasters unfamiliar with CCVs. This is a very important point because, on the one hand, emphasizes that CCVs share some sensory characteristics; on the other hand, every single vinegar differs for specific dominant notes.

The taste of Chinese cereal vinegars

Most of the judges perceived the 5 taste descriptors in all tasted vinegars, while only a few judges have not detected all descriptors in all vinegars. This remark is the same for trigeminal sensations. However, the intensity of taste perception for each descriptor varied greatly. Judges defined their own taste sensations with a three-degree score: high, medium and low/absent. In order to render the results in graphical form, the descriptive judgments have been converted to values, respectively 1 = high; 0.5 = medium and 0 = low / absent. To get the final score of any descriptor the following formula was applied: $[(1 \times N1 + 0.5 \times N2 + 0 \times N3) \times 100] / (N1 + N2 + N3)$, where N1, N2, and N3 are the number of judges who evaluated, respectively, high, medium or low the vinegar for that specific descriptor. In short, when the score is 100 all the judges find the vinegar at the highest level for that specific descriptor.

Figures 2, 3 and 4 show the radar chart of the taste of CCVs, grouped accordingly to their aging. Similarly to what observed for olfactory sensations, the tasted vinegars show shared taste impressions, while important differences were found among the different aged vinegars. For example, the trigeminal sensation *spicy* is frequently felt in aged and medium aged vinegars, but not in the youngest ones. It is important to remember that *spicy* refers to the trigeminal nerve irritation caused by spicy foods such as chili. The sensations of pungent and astringent are quite frequent and felt at high level, especially the first one, that is due to acetic acid content of the vinegars. The astringency is more common in young vinegars and it decreases with the ageing process. Regarding the taste, bitter is more common in medium-aged vinegar but not for all the vinegars: only the sample H2 and F2 show a remarkable bitter taste. In general, the main taste descriptors of CCVs are acid and salted, while sweet and umami are less frequent and rarely felt at high levels. The salted sensation is probably due to the added sodium chloride, but the contribute of other molecules, such as amino acids from raw materials, should not to be excluded.

Conclusions

In the present work, a preliminary descriptive language for CCVs was identified and proposed: 23 main olfactory descriptors were associated to the products, which were also characterized according to the yielded trigeminal sensations. CCVs share some olfactory descriptors such as: *meat broth*, *toasted*, *walnut*, *chocolate* and others, which are more peculiar for specific vinegars. Regarding the taste, *acid* and *salted* are the two descriptors universally present in all vinegars, while *sweet* is rarely felt and, when perceived, it is at very low intensity. The bitterness is peculiar of two medium matured vinegars and coming from two different districts. The last taste *umami* is poorly represented; this last observation is in apparent contradiction with the high frequency of the olfactory perception of *meat broth*. Indeed, it is a reasonable assumption that umami taste and broth smell are linked sensorial sensations. The reason why these two sensations resulted uncorrelated could be due to the judges' cultural background or, more probably, to the fact that many judges felt *umami* as a regular savory/salted taste. Trigeminal pungent sensation is a common trait

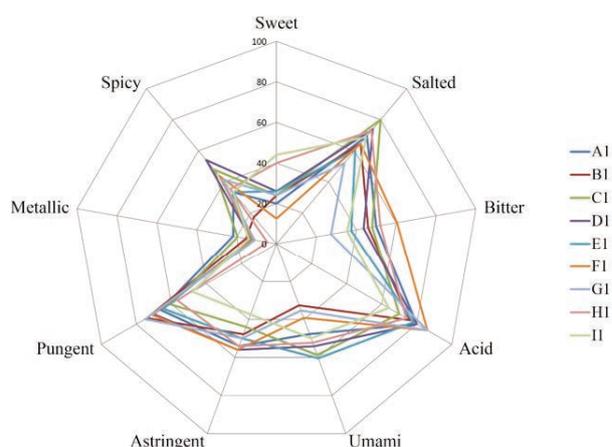


Figure 2. Radar chart of taste and trigeminal sensations of the most aged Chinese Cereal Vinegars. The capital letter refers to the different samples as reported in material and methods.

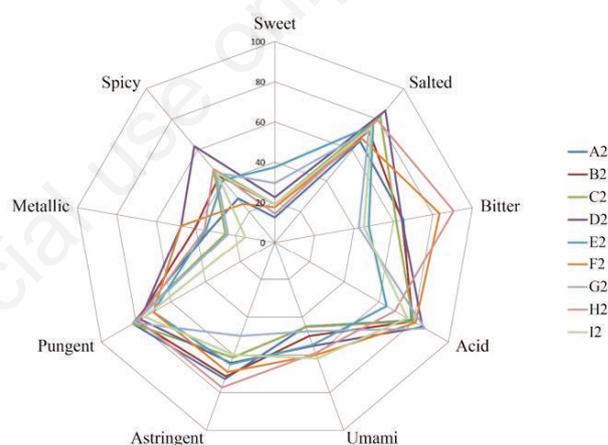


Figure 3. Radar chart of taste and trigeminal sensations of the medium-aged Chinese Cereal Vinegars. The capital letter refers to the different samples as reported in material and methods.

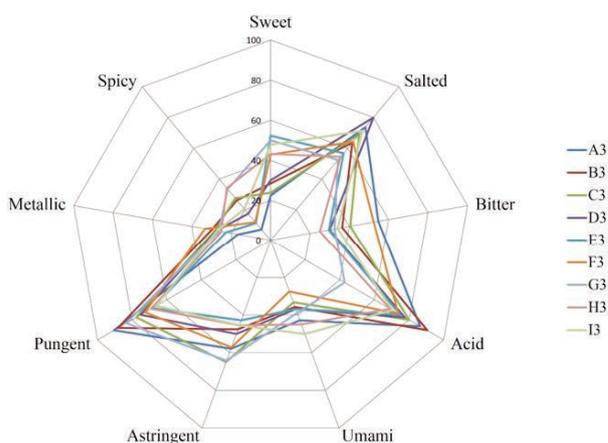


Figure 4. Radar chart of taste and trigeminal sensations of the less aged Chinese Cereal Vinegars. The capital letter refers to the different samples as reported in material and methods.

of all the CCVs, sometimes it is perceived very high and at other times it is more balanced. Whereas, *spicy* is less frequent and related to specific vinegars. Notwithstanding that this is a preliminary lexicon on the sensorial traits of CCVs, its value is due to the high number of trained judges with experiences on food and beverage, but without any experiences of CCVs. The absence of previous experience on CCVs is a guarantee of absolute independence in the sensorial perception during tasting. As it is well known, the inde-

pendence of judgment is a basic requirement for sensory evaluation.²¹ In our opinion, this basic lexicon could help in different points of the production chain and in the commercialization of CCVs: i) to improve the procedures of quality control; ii) to give useful sensory data to evaluate processes and raw materials; iii) to better compare analytical data and sensory properties; iv) to identify flavor characteristics that appeal to particular subsets of the global marketplace.

Table 2. Most frequent olfactory descriptors and terms used by the judges of the four different panels.

Descriptors	Terms used to describe sensorial attribute by different judges and grouped under common descriptors defined during the different panel discussions	No. of judges	%
Walnut	Hazelnut	51	73%
Licorice	Anise, Mint, Ginger, Tarragon, Dry orange peel, Lemon, Menthol	51	73%
Soy sauce	Broth, Cooked, Fish, Umami	46	66%
Hay	Cocoa, Coffee, The, Chocolate, Tobacco	44	63%
Toasted	Bread crust, Bread, Alcohol, Flour, Yeast	40	57%
Corn silage	Acid, Olive, Pungent, Cheese, Vomit, Sweat, Milk, Yogurt	40	57%
Burnt		40	57%
Caramel	Balsamic, Plum, Dark beer, Cooked must	39	56%
Leather	Tannin, Urine, Farm, Stable	38	54%
Drug	Glue, Vinegar, Acetic acid, Camphor, Chemical, Incense, Mothball, Paint	37	53%
Vanilla	Christmas cake, Cappuccino, Chocolate hazelnut	36	51%
Tobacco	Cocoa, Coffee, The, Chocolate, Hay	35	50%
Smoked	Rhubarb, spices	34	49%
Meat broth	Cooked, Fish, Soy sauce	32	46%
Grass cut	Poppy, Green tomato, Tomato leaf, Green pepper	31	44%
Molasses	Wax, Candied fruit, Raisin, Honey, Wine	29	41%
Bitter almond	Coriander	28	40%
Apple	Banana, Red fruit, Strawberry, Cherry, Unripe fruit	28	40%
Glue	Drug, Vinegar, Acetic acid, Camphor, Chemical, Incense, Mothball, Paint	26	37%
Clove	Nutmeg, Cinnamon, Pepper, Horseradish, Spices	26	37%
Chocolate	Cocoa, Coffee, The, Hay, Tobacco	25	36%
Banana	Apple, Red fruit, Strawberry, Cherry, Unripe fruit	25	36%
Mildew	Rotten, Moss	25	36%
Honey	Wax, Candied fruit, Raisin, Molasses, Wine	24	34%
Pepper	Nutmeg, Cinnamon, Clove, Horseradish, Spices	24	34%
Rancid		22	31%
Bran	Cereals, Malt	21	30%
Bread crust	Bread, Alcohol, Flour, Yeast, Toasted	19	27%
Yeast	Bread crust, Bread, Alcohol, Flour, Toasted	19	27%
Boiled cabbage	Savoy cabbage, Corn, Boiled potato	18	26%
Cheese	Corn silage, Acid, Olive, Pungent, Vomit, Sweat, Milk, Yogurt	17	24%
Coffee	Cocoa, Tobacco, Tea, Chocolate, Hay	14	20%
Flour	Bread crust, Bread, Alcohol, Toasted, Yeast	12	17%
Cocoa	Chocolate, Tobacco, Tea, Hay, Coffee	10	14%
Pop corn	Peanuts, Butter	8	11%
Anise	Licorice, Mint, Ginger, Tarragon, Dry orange peel, Lemon, Menthol	8	11%
Boiled potato	Savoy cabbage, Corn, Boiled cabbage	5	7%
Broth	Broth, Cooked, Fish, Soy sauce	4	6%
Wood	Sawdust, Cork	4	6%

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