Environmental Influences on the Sensory Quality of *Asparagus officinalis* L.

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Abstract

For asparagus the most important competition factors are sensory quality and freshness. The image of asparagus to be a vegetable of highest palatability increasingly needs to be justified and demonstrated. Therefore the aim of the study was to quantify the impact of cultivars, location, harvest date and year on the asparagus flavour quality. The varieties 'Huchels Alpha', 'Thielim' and 'Vulkan' were harvested from 2000 to 2002 at three locations in Germany. The material for the sensory and the analytical analyses was sampled four times over the cropping period. The human-sensory and the aroma analyses were carried out one day after sampling. A long-time trained panel carried out the human-sensory evaluations in two replications. The sensory parameters evaluated were subdivided into the direct odour (typical, sweetish, pungent, musty, earthy), the taste (bitter, sweet, typical, tasteless), the mouth sensation (metallic, astringent, crisp, tough, stringy), the aftertaste (bitter, astringent) and the non-dominant, occasionally appearing sensations (cake, bread, potato, soup, stinky, lemon-like, burnt, buttery, sour-like, flowery). Significant effects of variety, location, year and harvest date on the sensory impression and the aroma compounds could be found. The interactions of the main influencing factors are remarkable and they have to be considered in discussions and interpretations of sensory results.

INTRODUCTION

There are a lot of questions and opinions concerning the quality of asparagus. Each breeder and producer wishes the consumers entirely satisfied with their product. But asparagus is a very sensitive vegetable, reacting on the cultivation conditions as well as on long storage and shipping. Therefore freshness and regional circumstances are underlined in campaigns for asparagus. These facts rest on long-term empirical experiences. In former investigations over two years and two locations with eight varieties, it could be demonstrated that the cultivar has a significant effect on flavour and acceptability (Hoberg et al. 1997). This effect was stronger than those of the location, the harvest date, and the harvest year. The study reflects additional results of another model with more replications of the cultivation conditions.

MATERIALS AND METHODS

Materials

Three asparagus cultivars ('Huchels Alpha', 'Thielim', and 'Vulkan') were harvested in 2000, 2001 and 2002 in the experimental garden of the Federal Centre for Breeding Research on Cultivated Plants in Quedlinburg, in the asparagus fields of Alt Mölln (Northern Germany), and in Möringen (Central Germany). The characterization of the environmental influences is given in table 1. Every year the sampling was repeated four times in eight-day intervals (beginning, early middle, late middle, and end of the

season). The asparagus spears were cut randomly in two replications. The fresh asparagus was shipped cool, and analysed one day after sampling.

Methods

1. Sensory evaluation. The sensory evaluation of 27 sensory defining features was carried out by a trained panel consisting of 15 members with 6 samples per session (Hoberg, Ulrich et al. 1997). For quantitative descriptive analysis (QDA) the panellists quantified the features on a non-graduated 10 cm long linear scale. Generally the average value of all 15 panellists is used as one result for one sample in the statistical calculations. The acceptability was classified with „very high“ (5), „high“ (4), „middle“ (3), „low“ (2) and „very low“ (1).

2. Chemical analyses. Aroma extraction was carried out by simultaneous steam distillation-extraction (SDE) as described (Hoberg, Ulrich et al. 1997). The sample amount was 400 g of asparagus cuts. It was cooked directly in the SDE-apparatus with 800 ml of distilled water, and 1 g of sodium chloride. A volume of 30 ml of 1,1,2-trichloro trifluoro ethane („Kaltron“; FLUKA, art. no. 91440, puriss. p.a. >99.5 %; distilled) was added to the extraction device. The Likens-Nickerson extracts were concentrated from 30 ml to 100 µl in a modified Kuderna-Danish concentrator fitted with a three-ball Snyder column.

Gas chromatography-mass spectrometry - Hewlett-Packard MSD 5972 with HP 5890 Series 2 plus, data base NBS75K and Wiley 138; injector 250 °C; split 10 ml; column: INNO-wax 30 m x 0.25 mm ID / 0.5 µm; 1 ml helium/min; temperature programme: 45 °C - 2 grd/min - 200 °C.

Statistical methods

The statistical analyses were carried out with STATISTICA ™ for Windows from StatSoft, Inc., MS Office 2000 Excel, and FOX 3000, Vers. 4.0, from Alpha M.O.S.

RESULTS AND DISCUSSION

At first all sensory parameters were included in the analysis of variance. All main effects (cultivar, year, location, harvest date) and the interactions of these parameters were included. As post hoc-test the Tukeys Honest – Significance – Difference Test with $p = 0.05$ was used. All 27 sensory features were tested and 12 of them were found to be significantly different among the tested varieties. They are summarized in figure 1 and reflect the representative behaviour of the varieties over three years, three locations and four samplings. There are typical differences especially between ‘Thielim’ and two other varieties. The acceptability of ‘Thielim’ is significantly lower than for the others. It seems that the highest intensities of ‘bitter’, ‘metallic’, ‘astringent’ and ‘burnt’ in ‘Thielim’ cause this animosity. In contrast, the typical odour intensity is the highest in ‘Thielim’. ‘Huchels Alpha’ and ‘Vulkan’ are perceived as more ‘tasteless’, however also ‘sweeter’. ‘Huchels Alpha’ additionally has a fine ‘buttery’ odour occasionally occurring in asparagus. Asparagus always has a light earthy and musty odour; in ‘Vulkan’ this musty odour is so high that it tends to be unpleasant.

The most important characters for the consumers’ evaluation of the asparagus quality are in descending order of ‘stringy’, ‘bitter taste’, ‘sweet taste’ and ‘typical odour’. To meet these demands the correlations between acceptability and the distinct characters will be demonstrated in the figure 2. All correlation coefficients shown are significant. The acceptability closely depends on the bitter taste, followed by ‘stringy’, sweet taste and typical odour. The influence of bitter and sweet taste confirms former results (Hoberg et al. 2003). The strong correlation between acceptability and bitterness should be considered by breeders as well as by producers and traders. A too high bitterness level cannot be completely covered by preparation of the food.

The relatively weak correlation between acceptability and the typical odour can be explained by the fact that the typical asparagus odour is mainly caused by dimethyl sulfide, which occurs in all tested varieties in nearly the same high level, if they are

cultivated, shipped and prepared to eat in an identical manner (Freytag et al. 1968, Ney et al. 1972 and 1982). Only extreme other varieties like violet and green asparagus or different storage conditions before aroma analyses result in deviant perceptions by the ordinary consumers. But there are some important aroma substances (Ulrich et al. 2001), which can be detected by trained sensory testers (Hoberg et al. 2001). Applying principal component analysis it can be proved that these aroma component results (figure 3) show an influence of location and harvest date on the aroma profile. The discrimination power for these effects decreases from *(E)*-2-butenal, 2,3-butanedione (buttery, sweet, caramel), *(E)*-2-hexenal (green), phenyl acetaldehyde (flowery), 1-hexanol (fruity), 2,3-pentanedione (caramel-like), 1-methyl thiopropane (sulphurous), 2,3-octanedione (mushroom-like), 2-furancarboxaldehyde (cooked), 1-pentanol (fruity).

The results presented above reflect correlations based on an extensive pool of single measurements (n = 216) and have a general explanatory power. The application on single concrete cases of a location or cultivation conditions is problematic, which is explained in table 2. The effects of the four explanatory variables cultivar (n = 3), year (n = 3), location (n = 3), and harvest date (n = 4) for the demonstrated parameters are mostly significant at p = 0.05. Beyond it 17 two- and threefold interactions could be found to be significant.

CONCLUSION

The significant influence of cultivar, year, location and harvest date on the most important sensory characters could be proved. The results verify the formerly discussed approach to regulate flavour quality by breeding. On the other hand the dependence on the location and the interactive expression of certain quality features demand to adapt the cultivation of a concrete variety to the regional conditions. The manifold interactions of the explanatory variables bind to a careful interpretation of experimental results.

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Figures

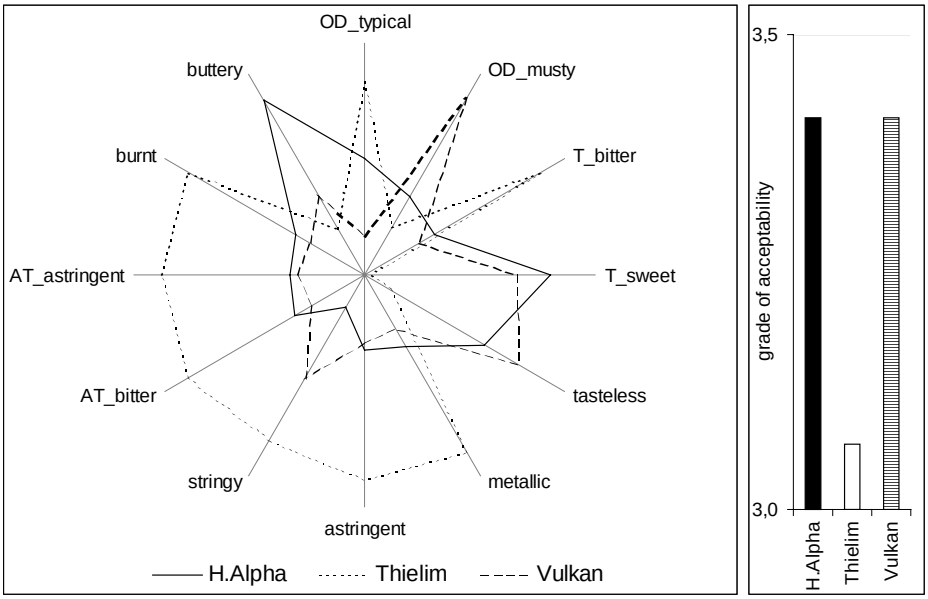

Fig. 1. Characterization of the varieties 'Huchels Alpha', 'Thielim', and 'Vulkan' by the standardized intensities of 12 sensory parameters and the acceptability. Means from three years, three locations, four harvest dates, and two replications, which are significantly distinct according to variety (OD: odour, T: taste, AT: aftertaste)

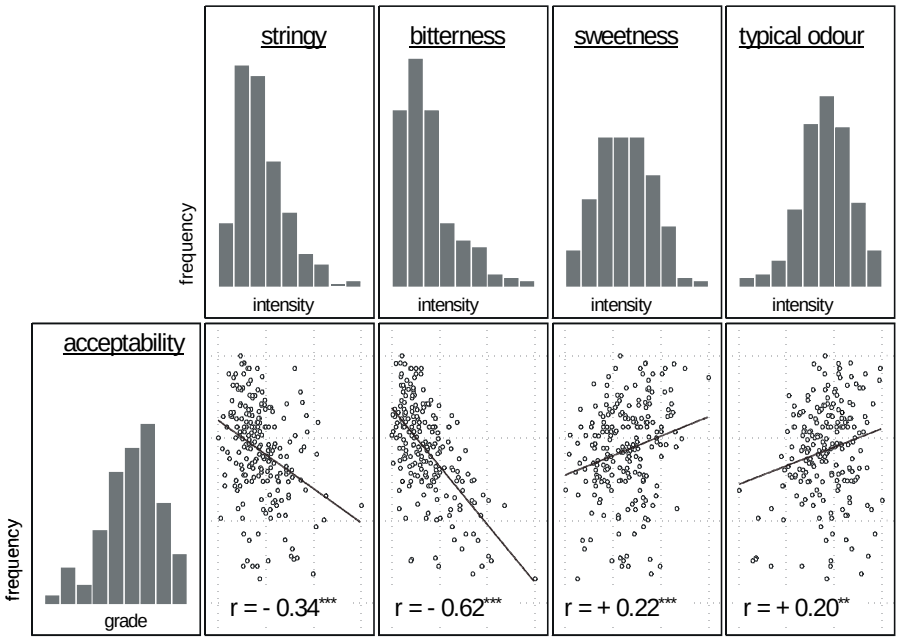

Fig. 2. Frequencies of the most important characters' intensities influencing the sensory asparagus quality, and the correlation between acceptability and the measured quality characters. Means of three varieties, three years, three locations, four harvest dates, and two replications (n = 216).

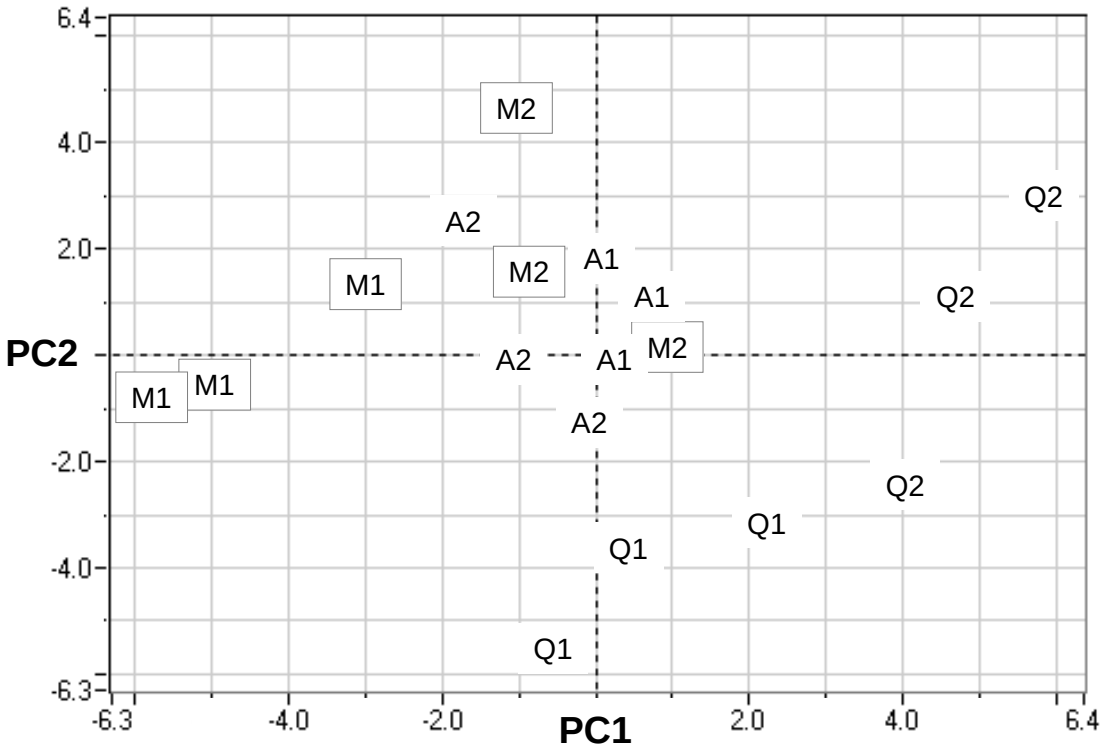

Fig. 3. Principal component analysis (PC scores 1 and 2) based on the relative concentrations of all aroma compounds. The data shown are averages from all varieties and are labelled for the locations (A: Alt Mölln, M: Möringen, Q: Quedlinburg) and the harvest (1: begin of the season, 2: late middle of the season). They demonstrate the influence of location and harvest date on the aroma profiles.

Tables Table 1. Characterization of the environmental influences by local and weather conditions

Location	Position above sea level (m)	Soil type	Valuation index of field	Long time mean - temperature (°C)	Long time mean - precipitation (mm)	Year	Month	Mean daily temperature (°C)	Precipitation (mm)	Date of the first harvest
Quedlinburg (Q)	140	loam	90 - 95	8.9	497	2000	April	10.3	50.8	02/05/00
							May	14.5	42.5	
							June	17.1	24.7	
						2001	April	7.9	23.7	07/05/01
							May	14.8	19.1	
							June	15.1	47.4	
						2002	April	7.4	46.3	13/05/02
							May	14.5	54.1	
							June	17.4	38.2	
Möringen (M)	36	sandy loam	45	9.2	520	2000	April	10.6	16.0	03/05/00
							May	15.1	45.0	
							June	17.1	33.0	
						2001	April	6.8	39.0	09/05/01
							May	14.5	15.0	
							June	14.5	68.5	
						2002	April	7.4	50.0	14/05/02
							May	14.4	87.0	
							June	17.5	75.5	
Alt-Mölln (A)	29	loamy sand	24	8.1	600	2000	April	10.3	26.2	03/05/00
							May	14.5	38.7	
							June	16.1	69.3	
						2001	April	7.6	69.5	16/05/01
							May	13.5	43.1	
							June	14.0	111.7	
						2002	April	8.3	54.5	15/05/02
							May	13.9	60.1	
							June	16.7	117.0	

Table 2. Survey over all significant effects on acceptability and the most important sensory parameters of asparagus (2 replications, n = 216, p = 0.05)

effect	acceptability	stringy	T_bitter	T_sweet	OD_typical
cultivar (C, n = 3)	x	x	x	x	x
year (Y, n = 3)		x	x	x	x
location (L, n = 3)	x	x	x	x	x
harvest (H, n = 4)	x	x		x	
Interactions					
(C)x (Y)					x
(C) x (L)				x	
(Y) x (L)		x	x	x	x
(C) x (H)	x				x
(Y) x (H)		x			x
(L) x (H)	x				
(C) x (Y) x (L)			x		
(C) x (Y) x (H)					
(C) x (L) x (H)		x	x		
(Y) x (L) x (H)		x		x	x
(C) x (Y) x (L) x (H)					