Journal of Applied Botany and Food Quality 80, 155 - 159 (2006)

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Distribution of nutritive compounds and sensory quality in the leafs of chives (*Allium schoenoprasum* L.)*

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(Received June 26, 2006)

Summary

The distribution of sulphur, thio-sulphinates (pyruvic acid method), SSC, colour, fresh- and dry matter was analysed in three sections, base, centre, and tip, along the leaf tube of chives. Also the intensity of 28 sensory attributes was determined in these sections by a trained quantitative, descriptive panel. The sections differed in their mouth-feel attributes – centre and basis were juicier and crisper than the tips, which were strawy/fibrous and drier. At higher pyruvic acid and SSC concentrations in the tips, more punceny and sweetness was expected, but no increased values were found. Very low juiciness to convey pungent and sweet compounds and very low fresh matter related to leaf length were identified as possible reasons for this inconsistency.

Introduction

Chive leaves, grown under greenhouse forcing conditions show a gradual change of green colour along the leaf tube. The earlier, prior plant parts toward the leaf tip have more time to synthesise chlorophyll, leading to more intensive, dark green colour. Basal leaf parts are often much brighter. According to observations in the production chain the brighter, basal parts offer an increased culinary quality, particularly because of more juiciness. Dissolved compounds in the augmented amount of juice may be the reason for increased flavour intensity. Preliminary measurements confirmed the assumed higher water content in these plant parts. Imported chives from Kenya or Israel, present on the market, show much less inhomogeneity with regard to colour, but compound and sensory quality distribution is not known.

If improved sensory properties of brighter leaf areas can be demonstrated scientifically, a balanced ratio of brighter and darker leaf sections should be recommended from a consumer perspective. This study was proposed to determine the distribution of nutritive and sensory properties along the leaf tubes of chives.

Material and methods

Plant material

German chive leaves (cv. Divonne, Rijk Zwaan, Welver) were harvested on June 5th , 2005 and delivered to the Gartenbauzentrale Papenburg after 3 to 5 days of forcing in the greenhouse according to usual professional methods. The Israeli chives were imported from Sharon Binyamin, Carmel, Israel and were obtained on the same day as the harvested material from the Gartenbauzentrale Papenburg. The Israeli and German samples were cooled during the ½ day road transport to Grossbeeren, Germany on June, 6th. Here the containers were opened and stored overnight at 4 ± 2 °C and 80 % relative humidity in a cold storage room. One half of the German samples was analysed together with the Israeli samples the next day. The other half of the German samples was stored for one week under the described cool storage conditions. The Israeli samples were not stored. Instead, fresh Israeli samples were obtained in the same manner one week later. Because the previous history of the Israeli chives was not known in detail, the samples were regarded as random samples.

Definition of leaf sections

The chive leaves were divided into three longitudinal sections. The basal part was cut at a length of 8 cm, the central part at 12 cm, and the tip end had a length of 8-12 cm according to the actual growth length. The analyses were conducted for all sections separately.

Colour measurement

Leaf colour was measured with a Minolta LR 321 colour-meter (Minolta Camera Co., Osaka, Japan) using a white standard and standardized light type D65. Colour measurements were expressed in the L*a*b* scale, where L* denotes luminescence on a 0 to 100 scale from black to white, a* (+) red or (-) green and b* (+) yellow or (-) blue light. An average of twenty single measurements on two bundles of chives was recorded for each sample.

Dry matter content, soluble solid compounds and weight loss

The dry matter content was determined after drying four replicates of 50 g each for three days at 80 °C. Soluble solids compounds (SSC) were determined by extracting the juice from at least 15 g fresh sample in a household centrifuge juicer and measured with a hand-held refractometer (digital refractometer PR-1, Atago, Tokyo, Japan). The measurement is based on the capacity of sugar in a juice to deviate light and gives the proximate sugar content in °Brix (Ahlers, 2001). Weight losses of four replicates with 50 g chive leaves in each sample were determined after a 24 hour period of uncovered storage in the cold storage room.

Pyruvic acid and sulphur

Total pyruvic acid (PA) was analysed in 20 g ruptured shoot tissue using the method described by Schwimmer et al. (1961) and Randle et al. (1993). The fresh shoot tissue was homogenised with 30 ml distilled water, after 20 min mixed with 5 % trichloroacetic acid solution (1:1) and left standing for 1h. The filtrate was mixed with the indicator 0.0125 % 2,4-dinitrophenylhydrazine in 2N HCl, then alkalined with 0.6 N NaOH, and the measured transmission at 420 nm. Background levels of PA of intact onion tissues were assumed to be negligible and constant (Yoo and Pike, 2001), so that background pyruvic acid was not measured.

Total sulphur was analysed in an elementary analyser (high temperature oxidation) and detected with non-dispersive infrared technique (NDIR) (multi EA 2000, Analytik Jena AG, Germany).

* The paper was presented at the 41th meeting of the „Deutsche Gesellschaft für Qualitätsforschung (Pflanzliche Nahrungsmittel) DGQ e.V.“

Sensory analysis

The descriptive sensory analysis was conducted to characterise the attributes of the different sections of the chive leaf material using a trained panel similar to the method of (STONE et al., 1993). Eight judges were selected who had successfully passed standardised tests for olfactory, taste and colour sensibility as well as for commemoration, verbal abilities and creativity. Approximately 20 h training over a 10-week period for establishing the methodological foundations was followed by another 20 h training with *Allium* species. Leaf samples were presented individually and in random order on a cutting board. Leaves were cut and squeezed according to a specified scheme. A four digit code was assigned to the samples. 28 odour-, flavour-, mouthfeel- and aftertaste attributes were distinguished and assessed using unstructured line scales with the anchor points 0 – not perceptible and 100 – strongly perceptible. Among the flavour attributes were: green/grassy, leek-like, garlic-like, onion-like, cabbage-like, sweet, bitter, fruity, earthy. Mouthfeel attributes were: burning/pungent, adstringent, dry/juicy, crisp, strawy/fibrous.

Statistical analyses

The data were analysed using the software packages Statistica V. 4.1 (Statsoft), and SPSS v. 7.5 (SPSS Inc.). Analytical data were subject to ANOVA and Duncan-Test at the significance level of p=0.05.

Tab. 1: Results of the instrumental colour measurement (CieLab-System).

	Luminescence L*	Green a*	Yellow b*
Germany 07.06.05			
Basis	53.5 g	-16.7 a	33.5 f
Centre	46.0 f	-16.8 a	29.9 e
Tip	38.9 d	-15.3 b	21.4 c
Germany 14.06.05			
Basis	53.4 g	- 16.4 a	34.7 f
Center	44.7 f	-16.9 a	29.4 e
Tip	38.6 cd	- 14.9 bc	21.2 c
Israel 07.06.05			
Basis	42.0 e	- 15.0 bc	24.1 d
Center	38.0 bcd	- 13.7 de	19.1b
Tip	36.5 abc	- 13.5 e	19.0 b
Israel 14.06.05			
Basis	39.9 d	- 14.4 cd	21.5 c
Center	35.9 ab	- 12.6 f	15.5 a
Tip	34.3 a	-11.8 g	14.2 a

Different subscript letters in a column indicate significant differences at the p=0.05 level.

Results

Instrumental colour values

The colour values differed between the three sections of both geographic origins in a similar way. The basal section was brighter, green and yellow colour notes were somewhat more intensive than the central and apical section. The section differences were minor in the Israeli samples.

Between the samples large luminescence (L*) differences were found (Tab. 1). Tips and central parts of Israeli chives produced values of 34 to 38 units, thus characterising dark material. The second sample was darker than the first. With L* values of 40 to 42 the basal sections were significantly brighter than the other sections. The German greenhouse samples were brighter than the Israeli samples. The luminescence values of the fresh German samples decreased significantly from the basis to the tip (Tab. 1). The one week storage period of the German chives had no influence on their luminescence (L*) values.

The intensity of green colour is indicated by negative a* values in the Cie-Lab system (Tab. 1). The tip and central sections of the Israeli samples were not always significantly different in their a* values. But the basal parts had significantly lower (greener) values at both sampling dates compared to the tip and central section. The German samples had lower a* values than the Israeli samples. The German samples were less green at the basal and central sections than the tip sections. There was no a* change during storage.
The figure b* indicates the intensity of yellow colour notes (Tab. 1). Similar to a* values, the Israeli b* values show a significant higher yellow colour intensity in the central and top sections compared to the basal section. The German samples had significantly increasing yellow colour intensities towards the tip of the leaf. Storage did not affect b* values.

Dry matter content

Dry matter content was significantly different between the sections (Tab. 2). The basal sections contained the least, the tip sections the highest percentage of dry matter per total mass. In all sections the Israeli samples had significantly higher dry matter ratio than the German samples. After storage the dry matter ratio of German samples was significantly higher in the central section only.

Soluble solid compounds

The concentration of soluble solid compounds (SSC) increased from the basis towards to the tips (Tab. 2). Very high values were detected in one sample from Israel; but at both dates, the Israeli samples had higher concentrations in all sections compared to the Papenburg material. Storage led to a slight, not significant increase of SSC in each of the three sections.

Weight loss

No differences were found in the weight loss of all samples and between the sections, because of large variation within the material. There was a tendency for higher losses in the tip section of the leaves, especially in stored German sample (Tab. 2).

Pyruvic acid concentration

The indirect pyruvic acid method allows to determine the amount of thio-sulphinates, organo-sulphur compounds, which are responsible for the *Allium* flavours and pungency (RANDLE, 1992; RANDLE et al., 1993).
The pyruvic acid concentration was highest in the tip sections, and slightly lower in the central and basal sections (Tab. 3). Only in the Israeli sample this difference was significant.
The pyruvic acid concentration in the chive leaves from Germany was in all sections significantly higher than those in the Israeli samples. The one week storage of the German sample did not affect pyruvic acid contents.

Tab. 2: Dry matter ratio, soluble solid compounds and weight loss

	Dry matter (%)	Soluble solid compounds (°Brix)	Weight loss (%)
Germany 07.60.05			
Basis	6.31 a	3.90 a	15.10 ab
Centre	6.86 a	4.20 ab	18.55 ab
Tip	8.52 de	5.43 cd	18.75 ab
Germany 14.06.05			
Basis	6.42 a	4.69 abc	17.95 ab
Centre	7.42 b	4.90 bcd	17.80 ab
Tip	9.03 ef	5.75 de	22.25 b
Israel 07.06.05			
Basis	8.08 cd	4.31 ab	13.65 a
Centre	9.19 f	5.05 bcd	13.75 a
Tip	11.37 h	6.46 ef	17.35 ab
Israel 14.06.05			
Basis	7.80 bc	5.40 cd	16.65 ab
Centre	8.94 ef	7.03 fg	14.55 a
Tip	10.73 g	7.74 g	18.65 ab

Different subscript letters in a column indicate significant differences at the p=0.05 level.

Tab. 3: Pyruvic acid concentration related to fresh matter.

Pyruvic acid (µmol/gFM)	German sample fresh	German sample stored	Israeli sample first date
Basis	12.813 c	14.589 cd	6.459 a
Centre	13.404 c	13.934 cd	6.128 a
Tip	14.060 cd	15.474 d	8.387 b

Different subscript letters in a row or column indicate significant differences at the p=0.05 level.

Sulphur concentration

Many compounds of *Allium* species, responsible for aroma and human health related effects, contain sulphur as unique organosulphur compounds (GOLDMAN et al., 1999). A high concentration of total sulphur in the chive leaves may lead to a high concentration of organosulphur compounds, and thus increased health relevance.

The concentration of total sulphur in the fresh matter of the different leaf sections corresponded with the concentration of pyruvic acid. The highest concentrations of sulphur in all samples were found at the tip, the lowest values at the leaf basis (Tab. 4). During the one week storage of the German samples, significant losses of sulphur were recorded. The total amount of sulphur was reduced by 25 %, probably because of gaseous losses. Beside these losses, the remaining concentration was higher than in the Israeli material. Sulphur content in plants can not only be influenced by processes after harvest, but also by sulphur fertilisation.

Distribution of fresh matter

Fresh matter was not evenly distributed along the length of the leaves. In the basal section with its bulkier and more succulent tubes 43.7 % of the total fresh matter were allocated, 39.4 % in the centre and 16.9 % in the tip sections of German samples. In Israeli chives 41.3 % were found in the basal section, 41.6 % in the centre and in the tips only 17.1 % of the total fresh matter was allocated. The order of increasing contents was reverted, when absolute contents of sulphur and pyruvic acid in the different sections were calculated (Tab. 5).

Sensory attributes

The perceivable sensory attributes are crucial for the consumer appreciation of a food product, but sensory determination of product attributes, especially of fresh fruit and vegetables are performed not on a regular basis. Often the concentration of compounds is used to estimate sensory properties, but interaction of attributes can lead to modification of the correlation of compounds and sensory attributes (LAVIN et al., 1998; LAWLESS et al., 1998; BRÜCKNER et al., 2000; BRUCKNER et al., 2005).

Tab. 4: Total sulphur concentration related to fresh matter (mg/100g FM)

Sulphur concentration (mg/100 g FM)	German sample fresh	German sample stored	Israeli sample first date	Israeli sample second date
Basis	77.6 e	53.2 cd	33.0 a	29.9 a
Centre	80.1 ef	59.0 d	38.6 ab	31.0 a
Tip	88.4 f	62.1 d	55.2 cd	46.0 bc

Different subscript letters in a row or column indicate significant differences at the p=0.05 level.

Tab. 5: Absolute amount of sulphur and pyruvic acid contained in the different sections of the chive leaves.

	Total sulphur (mg)		Pyruvic acid (µmol)	
in 100 g chives, compounds are contained in the	**German sample fresh**	**Israeli sample first date**	**German sample fresh**	**Israeli sample first date**
Basis	33.9	13.6	559	267
Centre	31.6	16.1	529	255
Tip	14.9	9.4	238	143
Sum	**80.4**	**39.1**	**1326**	**665**

Sensory differences between the sections

Several sensory attributes of the sections differed significantly. The most pronounced differences were identified in the mouthfeel modality. Tips were far less juicy and crisp, but more strawy/fibrous and drier (Fig. 2). The flavour attributes differed little between the sections. Despite the increased concentration of pyruvic acid (related to fresh matter), which should indicate higher pungency, the perceived pungency of the tips was not above that of the central and the basal section (Fig. 3).

The concentration of soluble solid compounds (SSC) was higher in the leaf tips compared to the central and basal sections (Fig. 4). The difference and the absolute values were even higher in the Israeli samples, than in the German samples. SSC concentration usually indicates sugar concentration, but sweetness was even lower in the tips in Israeli material.

Sensory changes after one week storage of German chive

Sensory changes during the one week storage of the German chives were small but in some cases significant. Strawy/fibrous mouthfeel increased (Fig. 2), onion flavour and green/grassy notes decreased (Fig 1).

Comparison of the sensory attributes of German and Israeli chives

The Israeli samples differed in their attributes juicy, not dry, crispy, strawy/fibrous. But Israeli samples of both dates were much less juicy and crispy and more strawy/fibrous and drier than the German sample. The Israeli sample of the first date differed even more from the German sample than the Israeli sample of the second date, in which the sensory intensities of the basal section coincided with those of the tip section of the German sample.

Pungent notes of German samples were significantly more intensive than of both Israeli samples, which were well correlated with the pyruvic acid concentration (Fig. 3). Sweetness of the German sample was intermediate, above the first, but below the second Israeli sample (Fig. 4). The concentration of SSC was higher in both Israeli samples but very low juiciness may have modified the perception of sweetness. Chive- and leek-like notes were also more intensive in the German sample.

Conclusion

The properties of chives are not distributed evenly along the leaf tube. Younger tissue, especially when forced in the greenhouse contains more water, which leads to more juiciness and less strawy or fibrous impressions. Though the older tissue towards the tips contains higher organosulphur compound concentrations on a fresh weight basis, flavour was not perceived more intensive. The tips of the German sample were in its colour and mouthfeel properties partly comparable to those of the central and basal part of the Israeli samples. But towards its basal parts the German chives were juicier, whereas the tips of the Israeli material were even less juicy and more strawy and fibrous.

The reason for the large differences in SSC and organosulphur compounds between the German and Israeli material is not known. Therefore the different growing conditions and cultivar differences should be studied in this respect.

Another important question is, how the significant sensory differences in appearance, colour, mouthfeel and flavour and their combinations can influence consumer appreciation and preference.

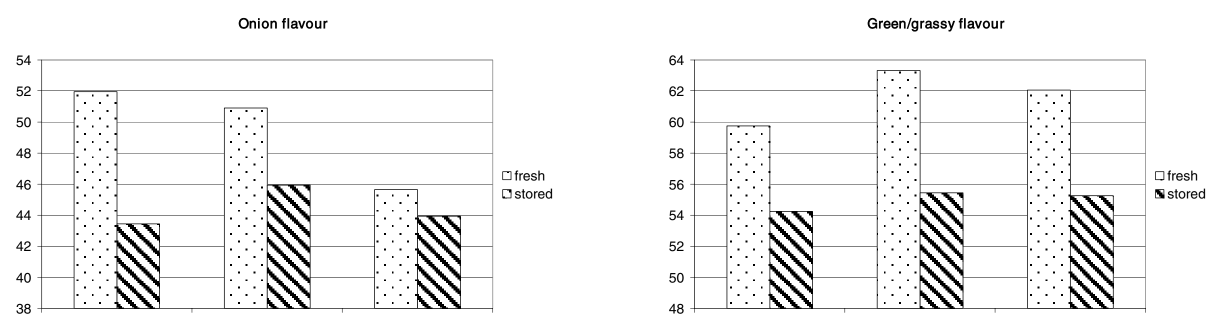

Fig 1: Intensities of the sensory flavour attributes onion (left) and green/grassy (right).

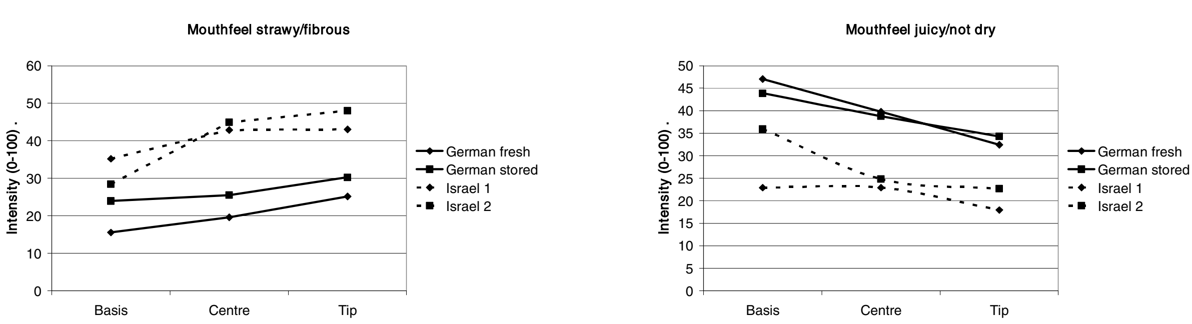

Fig 2: Intensities of the sensory mouthfeel attributes strawy/fibrous (left) and juicy, not dry (right).

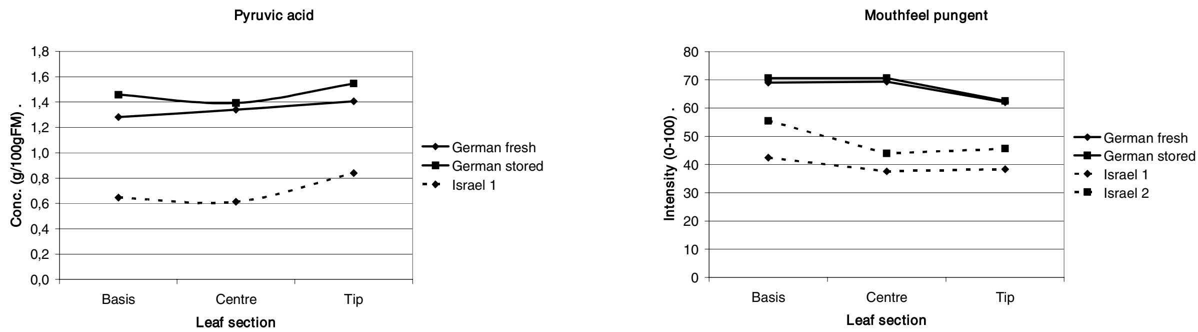

Fig. 3: Results of the instrumental determination of the pyruvic acid concentration (left) and the intensity of the sensory mouthfeel attribute pungent (right).

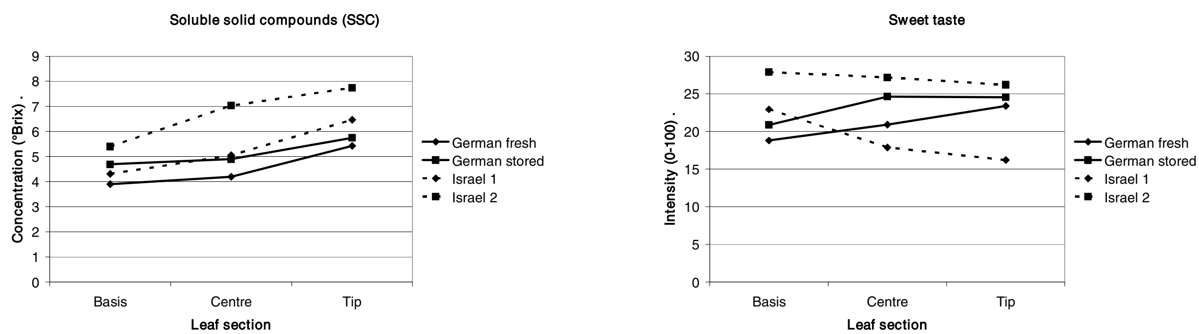

Fig. 4: Concentration of soluble solid compounds (SSC), (left) and intensity of the sensory taste attribute sweet (right).

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