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Physicochemical Changes and Sensory Evaluation of Slicing Cucumbers from different Origins

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Summary

Consumers are becoming increasingly demanding with regard to vegetable quality. For slicing cucumbers, appearance and shelf life are often described. However, little is known about taste. The main objective of this paper was to describe physicochemical parameters of slicing cucumbers and their relation to consumer sensory evaluation. Shrink filmed slicing cucumbers (*Cucumis sativus* L.) from eight different producers, four Norwegian and four Spanish, were obtained through Norwegian wholesalers. The fruits were analysed on arrival and during four weeks of storage at 12 °C in darkness. On arrival, significant differences between cucumbers from different producers were found for all measured physicochemical parameters: fruit length, weight, diameter, colour, endocarp diameter, dry matter content, firmness, soluble solid content (SSC), electrical conductivity (EC), total titratable acids (TTA), content of fructose, glucose, sucrose, malic and citric acids. During storage the green colour faded, and there was a reduction in dry matter, firmness and EC, whereas SSC and TTA increased. At harvest fructose, glucose and sucrose were the main sugars with a relative distribution of 48, 35 and 15 % respectively. Malic acid was the main organic acid (64 %). During storage citric acid content raised from 211 to 266 mg 100 g^{-1} fresh weight. Sensory evaluation showed significant differences between cucumbers from different producers. A positive correlation was obtained for consumer preference and SSC, whilst a negative correlation was found towards EC. A strong correlation (r = 0.96) was revealed between consumer preference and the relation $SSC^2 \times (TTA \times EC)^{-1}$. This indicates that consumer preference for cucumbers might be predicted by measurements of SSC, TTA and EC.

Key words. *Cucumis sativus* L. – EC – firmness – organic acids – preference test – SSC – sugars – TTA – triangle test

Introduction

Cucumber (*Cucumis sativus* L.) is a widely cultivated plant within the gourd family *Cucurbitaceae*. Next to tomatoes, cabbage, and onions, cucumbers are the fourth most widely cultivated vegetable in the world (Fao 2011). 'Slicing cucumbers' are produced for fresh consumption. In Europe, only a few numbers of slicing cultivars lacking a bitter taste have gained popularity among producers. These are characteristic with respect to size and skin thickness, and are not suited for long storage. The main deteriorative changes in cucumber during storage and distribution are yellowing, moisture loss which leads to shriveling, and physiological injury caused by low temperature (Adamicki 1985).

Main quality parameters of cucumber are flavour in terms of sweetness, sourness and aroma, in addition to fruit size, colour and texture (Zhou and McFeeters 1998; Dhall et al. 2011). There is a scarcity in literature with respect to quality studies of slicing in contrast to pickling cucumber. The composition of pickling cucumbers varies with fruit size and cultivar, but the cultivars are similar in terms of which compounds contribute to sweetness and sourness, though the quantitative patterns vary (McFeeters et al. 1982; McFeeters and Lovdal 1987). The major sugars reported to occur in pickling cucumber are fructose, glucose and to a less extent sucrose (Pharr et al. 1977; Handley et al. 1983; Li et al. 2002). Cucumber peel tissue contains 4 to 5-fold higher sugar concentrations than either the mesocarp or endocarp tissues (McFeeters and Lovdal 1987). Sugar concentrations have been found to be invariable with fruit maturation both in mesocarp and endocarp tissues (Handley et al. 1983). The main organic acids in slicing cucumber are malic and citric acid (Hirose 1976). Malic acid was found to be the major organic acid in pickling cucumbers, and the concentration was found to be highest in the outer mesocarp, followed by the endocarp, the inner mesocarp and the exo-

carp. Moreover, during enlargement and maturation of these cucumbers, citric acid became the principal organic acid reaching level above 1 % FW, which gave a decrease in endocarp pH (McFeeters et al. 1982; Handley et al. 1983). The decrease in pH correlated with loss in chlorophyll. Mesocarp and endocarp malic acid concentration did not change during fruit maturation (Handley et al. 1983).

Flavour, which is comprised of aroma and taste, is an important part of food quality (Shewfelt 1993). Relationships between fruit characteristics and consumer preferences for fresh tomato have been widely studied (Causse et al. 2010). However, there is little published information on sensory of fresh cucumber flavour. Since cucumbers fruit contain comparatively poor nutritive substances, it is not clear if differences in taste between cucumbers from different cultivars, producers or origins might even be expected. Consumer sensory analysis of organically and conventionally grown cucumbers showed no differences (Zhao et al. 2007). Taste descriptors like sweetness and sourness are commonly correlated to nonvolatile components and related to analysis of pH, titratable acids, soluble solids, glucose, fructose, total sugars or sucrose equivalents (Abegaz et al. 2004). Also cucumber texture or firmness might contribute to consumer preferences (Causse et al. 2010).

The purpose of this research was a) to study sensory quality of slicing cucumbers from several Norwegian and Spanish producers along shelf life, and b) to correlate physicochemical data with results obtained through taste tests.

Materials and Methods

Samples

Slicing cucumbers from eight different origins were used to achieve variability in cucumber quality. Cucumbers were grown at the same time in late winter in Norway and Spain to assure differences in climatic and growing conditions. In Spain, cucumbers are grown in plastic tunnels in the soil, while in Norway, cucumbers are grown in heated greenhouses using artificial light. Cucumbers were received from eight different growers, all growing different varieties, through four Norwegian wholesalers (Coop, Bama, ICA and Gustavsen). Each wholesaler delivered a random sample from a producer in Norway (Nor 1 to 4) and a producer in Spain (Spa 1 to 4). Each sample consisted of 18 shrink filmed slicing cucumbers. Samples were delivered on Monday in week 5 (2012), and the procedure was repeated in week 6 and 7, each time with samples from the same producers. Six samples (Nor 1 to 3 and Spa 1 to 3) were conventionally grown cucumbers, while two samples (Nor 4 and Spa 4) were organic grown cucumbers. Norwegian samples were harvested one day before arrival, while Spanish samples were harvested four to five days before arrival due to the longer transport route to Norway. The cucumbers were stored in a 25 m^3 storage room with forced ventilation at 12 °C (± 0.5 °C) in the darkness and a relative humidity of 85 % (± 5 %). Samples were analysed at day 1, 14 and 28 from arrival date. Samples showing visible damages or microbiological decay were excluded.

Analysis

Out of the eighteen cucumbers in each sample, nine fruits were individually analysed, three directly after receiving the fruits, followed by three after two and three after four weeks of storage. Sampling was repeated three times during the project period. That gave in total 3 × 3 × 3 cucumbers as basis for statistical measurements for the results of physical and chemical analyses. Fruit weight, length, diameter and endocarp diameter were measured for all samples (Table 1). Colour was compared to a colour map (Munsell plant tissue colour chart), where colour 3/4 was assigned 9 (mature green), 4/8 was assigned as 8, 5/8 as 7, 6/8 as 6 and colour 7/8 was assigned value 5 (light green). Dry matter was determined by drying two slices of approximately 15 g each at 60 °C for 48 h. The slices were taken from the mid part of the fruits. Firmness was measured at the inner mesocarp area of a fresh cut sliced cucumber by using a durometer (Durofel, Agro-Technologies, France) with values in the range 100 (high firmness) to 0 (low firmness). Electrical conductivity (EC), soluble solid content (SSC), together with total titratable acid (TTA) was determined from juice produced by crushing cucumber slices with a food processor. EC was measured using an EC meter (Priva, The Netherlands). SSC was measured by use of a digital PR-100α refractometer (Atago Co., Japan) and data were expressed as equivalent ºBrix (or %SSC) (Mitcham et al. 1996). TTA was determined by titration against 0.1 M NaOH by use of a 794 Basic Titrino instrument (Metrohm, Switzerland). The titration end points were chosen to be the closest equivalent point to pH 8.0. Titration results are calculated as citric acid equivalents, CAE, per 100 g of cucumber juice.

Samples for analyses of sugars and acids by HPLC were prepared by cutting two slices of 1 cm width from the middle of the fruit. These were immediately frozen in liquid nitrogen, and stored at −20 °C until analysis. One sample, Nor 4 from week 5, was separated into peel, mesocarp and endocarp for determination of concentration differences of sugars and acids within the fruit. Upon analysis, all samples were thawed and juice filtered through a piece of cotton cloth by pressing the fruit by hand. After centrifugation at 3500 rpm for 10 min, the juice was filtered through a 0.45 μm Nylon filter and analysed by HPLC.

An Agilent 1100-system (Agilent Technologies) was used for the analyses of both acids and sugars. Acids were separated on a Prevail Organic Acid column, 150 × 4.6 mm, 5 μm (Alltech Associated Inc, IL) at column temperature of 50 °C, and with a combination of two solvents; A: 25 mM KH_2PO_4 pH 2.5 (with H_3PO_4) and B: 90 % MeOH. The elution profile was (B in A): 0 % (for 20 min), 0–100 %

Table 1. Quality parameters fruit length, weight, diameter, colour, endocarp diameter, dry matter content, fruit firmness, soluble solid content (SSC), electrical conductivity (EC) and total titratable acid content (TTA) of slicing cucumbers from different producers in Norway (Nor 1 to 4) and in Spain (Spa 1 to 4). Average of fruits received in week 5, 6 and 7 (2012). Each sample consists of 27 fruits. Quality parameters were measured on arrival and after two and four weeks of storage at 12 °C in darkness.

Sample/ Storage	Length (cm)	Weight (g)	Diameter (mm)	Colour (0–9)	Endocarp (% of diameter)	Dry matter (%)	Firmness (0–100)	SSC (°Brix)	EC (mS cm^{-1})	TTA (mg CAE 100 g^{-1} juice)
Nor 1	32.5 a[+]	359 a	36.5 d	8.5 a	47 d	3.81 a	81 a	3.2 a	3.6 ab	103 bc
Nor 2	30.9 bc	351 ab	38.6 bc	8.3 ab	48 d	3.28 b	82 a	2.7 b	3.6 ab	97 bc
Nor 3	26.8 d	300 d	37.9 cd	7.6 c	53 bc	3.04 c	79 a	2.5 b	3.8 a	102 bc
Nor 4	29.8 c	322 cd	37.7 cd	7.9 bc	53 bc	3.76 a	79 a	3.1 a	3.0 cd	87 bc
Spa 1	26.8 d	313 cd	40.6 a	7.6 c	58 a	4.06 a	72 b	3.3 a	3.3 bc	149 a
Spa 2	30.3 c	331 bc	38.7 bc	7.5 c	59 a	3.79 a	78 a	3.1 a	3.2 bcd	84 bc
Spa 3	29.8 c	349 ab	39.9 ab	7.7 c	56 ab	3.92 a	71 b	3.3 a	3.4 abc	113 b
Spa 4	31.8 ab	352 ab	37.7 cd	7.7 c	50 cd	3.78 a	79 a	3.1 a	2.8 d	81 c
Nor	30.0 a	333 a	37.7 b	8.1 a	50 b	3.47 b	80 a	2.9 b	3.5 a	97 b
Spa	29.7 a	336 a	39.2 a	7.7 b	56 a	3.89 a	75 b	3.2 a	3.2 b	107 a
Storage (weeks)										
0	29.9 a	336 a	38.4 a	8.4 a	53 a	3.86 a	82 a	3.3 a	3.7 a	89 b
2	29.7 a	331 a	38.2 a	7.8 b	53 a	3.64 b	79 b	3.0 b	3.4 b	98 b
4	30.1 a	336 a	38.6 a	7.4 c	53 a	3.51 b	73 c	2.8 c	2.9 c	116 a
Sample* Storage	NS	NS	NS	***	NS	NS	***	NS	NS	***

***, NS: Significant at $P < 0.001$, or not significant, respectively.

[+] Values followed by different letters are significantly different according to SNK-test at $P < 0.05$.

(in 10 min), 100 % (for 5 min), 100–0 % (in 5 min), and finally recondition of the column for 5 min. Flow rate was set to 0.8 mL min^{-1}, whereas injection volume was 10 µL. Detection was made at 210 nm. Sugars within the same samples were separated on a Prevail Carbohydrate ES column, 53 × 7.0 mm, 5 µm (Grace, IL) at 25 °C with another combination of two solvents; A: MeCN and B: H_2O. The elution profile was (B in A): 10–35 % (in 7 min), 35–10 % (in 2 min), and finally recondition of the column for 1 min. Flow rate was set to 1.6 mL min^{-1}, injection volume to 10 µL. Sugars were detected by means of evaporative light scattering detection (ELSD 800, Alltech) with N_2-pressure at 2 bar, tube temperature at 65 °C, and gain 4. Solutions of authentic compounds were used for quantification.

Consumer panel

Consumer sensory evaluation was made up of two different elements: a triangle test (Iso 4120:2004) and a paired preference test (Meilgaard et al. 2007). A total of 24 consumers, 11 males, 13 females, aged 24–65 years, participated in the study. Panelists were drawn from a group of 80 volunteers working at the Rogaland Landbrukspark, Norway. Samples from conventionally grown cucumbers from Norwegian greenhouses (Nor 1 to 3) were compared to samples from Spain (Spa 1 to 3), and samples from organically grown cucumbers from Norwegian greenhouses (Nor 4) were compared to organic grown slicing cucumbers from Spain (Spa 4).

The triangle test was conducted according to the guidelines set out in Iso 4120:2004. The subjects were presented with tree samples and were advised that two samples were identical and one was different. The subjects were asked to taste each sample from left to right and select the odd sample. The subjects were forced to make a decision. Samples were tested within one day after arrival from the wholesalers and between 11:00 AM and 1:00 PM. Cucumbers were stored at 12 °C in darkness with a relative humidity at 85 % until 2 hours prior

to testing. Samples were prepared one hour prior to evaluation. Slices, 1 cm thick, were taken from the central part (15 cm) of the cucumber and placed in coded and randomized cupcakes using the combinations ABB, BAB, BBA, AAB, ABA, BAA. Samples were covered to avoid any visual effects. Each panelist performed four tests. The whole procedure was repeated three times, in week 5, 6 and 7, 2012, giving a total of 288 triangle tests. Panelists tasted samples at a self-determined pace and were provided with fresh spring water for palate cleansing.

Following the triangle test, the panelists were required to participate in a paired preference test (Meilgaard et al. 2007) where panelists received two samples in simultaneous presentation, half in the order A–B, the other half B–A. Samples were pre-coded with three digit random number. The subjects were asked to identify the preferred sample. The subjects were forced to make a choice.

Data analysis

The physicochemical data were subjected to analysis of variance using the General Linear Models procedure from the Statistical Analysis Software program (SAS version 9.2). The Student Newman Keuls multiple range test was used to determinate significant differences at a level of significance of $P < 0.05$. Correlation coefficients were calculated using the CORR statement. The results of the paired preference tests were analysed using binomial probability and the frequency procedure was used to determine the number of consumers who correctly identified the odd sample in the triangle test. Statistical significance of the results of the triangle test was determined from the table in Iso 4120:2004.

Results and Discussion

The slicing cucumbers were found to have small variations with respect to length and weight (Table 1). The mean fruit length was found to be 29.9 cm, whereas the net mass was 334 g. Significant difference in fruit length and weight were detected among cucumbers from different growers, but not between the Norwegian grown cucumbers compared to the Spanish ones. The uniformity may in part be due to similarity with respect to cultivars and standardized production methods, and in part due to EU regulations and demands of the wholesalers which allow only standard size cucumbers in the market. With respect to fruit diameter, which was measured at the middle of the cucumber, Spanish cucumbers were slightly bigger in size because of greater endocarp tissues (Table 1). None of the parameters connected to cucumber size changed during the four weeks of storage. The avoidance of water loss is mainly due to sealing of the cucumbers. Sealing in terms of individual shrink wrapping has become a routine procedure which prolongs the cucumber shelf life considerably (Dhall et al. 2011).

The colour of cucumbers from the different producers was in the range 8.5 (the most green) through 7.5 (less green). A difference between Norwegian and Spanish cucumbers was observed with the Spanish ones being less green. During storage, a significant yellowing took place, and a significant interaction in colour reduction between producer and storage time was found (Table 1). Colour reduction was most obvious for Spa 1, while Nor 1 kept best colour during storage (Table 2). It is known that cucumbers are susceptible to chilling injury at 10 °C or lower, and yellowing at 15 °C or higher (Dhall et al. 2011). The storage temperature at 12 °C should thus not

Table 2. Weekly changes in colour, firmness and total tritratable acid content (TTA) in cucumbers from different Norwegian (Nor 1 to 4) and Spanish (Spa 1 to 4) growers from harvest during four weeks of storage. Average of fruits received in week 5, 6 and 7 (2012). Each sample consists of 27 fruits.

Sample	Colour (0–9) week^{-1}	Firmness (0–100) week^{-1}	TTA (mg CAE 100g^{-1} juice) week^{-1}
Nor 1	−0.11 a^{+}	−0.0 a	−4 a
Nor 2	−0.30 bc	−0.0 a	9 bc
Nor 3	−0.33 bc	−1.4 bc	1 ab
Nor 4	−0.18 ab	−0.9 b	4 ab
Spa 1	−0.47 c	−5.1 e	15 c
Spa 2	−0.38 bc	−2.7 cd	7 bc
Spa 3	−0.22 ab	−3.7 d	3 ab
Spa 4	−0.16 ab	−1.4 bc	13 c
Contrast 'Nor–Spa'	NS	***	*

Significance of differences between 'Nor' and 'Spa' samples is given: NS: not significant, * $P < 0.05$; ** $P < 0.01$; *** $P < 0.001$.
$^{+}$ Values followed by different letters are significantly different according to SNK-test at $P < 0.05$ level.

trigger a temperature dependent colour change, but temperature variations during transport may have altered this. The less green colour of the Spanish cucumbers might partly be explained by a longer transport period which makes these fruits three to four days older than the Norwegian cucumbers in this trial.

Fruit firmness measured at the inner mesocarp tissue was found to be high in fresh cucumber, but declined during storage (Table 1). The Norwegian grown versus Spanish fruits were different as the Norwegian ones were found to be firmer. Also during storage, fruit firmness declined more in Spanish cucumbers when compared to Norwegian cucumbers (Table 2). A negative correlation between firmness and fruit diameter was detected (r = −0.57). A similar effect has been found with pickling cucumbers (Thompson et al. 1982). Cucumber firmness is an important quality issue, and efforts are made to keep this high. Firmness appeared to be different within the different parts of a cucumber fruit. Thompson et al. (1982) reported that by using a penetration force method, mesocarp tissues were five times firmer than endocarp tissues. Overall firmness is higher near the stem than near the blossom end. A positive correlation has been found between firmness and total amount of cell wall sugars in the fresh tissue (McFeeters and Lovdal 1987).

The dry weight content was found to be in the range from 3.04 to 4.06 % (Table 1). This is consistent with dry matter found in the cultivars 'Pacto' and 'Melen' (Gajc-Wolska et al. 2010). A decrease in dry weight content was found during the first two weeks of storage, but no significant change occurred later on. The dry weight content correlated (r = 0.77) with that of soluble solids (SSC). In both cases the contents were higher in cucumbers that had been produced in Spain than those of Norwegian origin. The SSC declined significantly during storage. It should be noticed that in spite of these reductions no change was observed with respect to cucumber net weights (Table 1). Likewise with the electrical conductivity (EC), storage resembled the value of EC to that of SSC revealing a decline in EC of the cucumbers during storage. Small differences were detected between Spanish and Norwegian fruits with the Spanish having the highest SSC and the Norwegian having the highest EC. The decline in SSC during storage follows that of the total amount of individual sugars (Table 3). The sugar content in cucumbers received in week 5 ranged from 1.93 g FW in fresh cucumbers to 1.58 g $100g^{-1}$ FW in fruits stored for four weeks. Fructose, glucose and sucrose made up 48, 36 and 16 %, respectively of the total sugar content in the slicing cucumbers. Literature based on a pickling cultivar reported

Table 3. Content of sugars (g 100^{-1} g FW) and acids (mg GAE 100^{-1} g FW) of Norwegian (Nor 1 to 3) and Spanish (Spa 1 to 3) cucumbers received in week 5 2012, during storage for up to 4 weeks, and of Norwegian (Nor 4) and Spanish (Spa 4) cucumbers received in week 7 2012. Each sample consists of three fruits.

Origin	Weeks of storage	Fructose	Glucose	Sucrose	Sum sugars	Malic	Citric	Sum acids
Nor 1	0	0.65	0.61	0.26	1.52	179	28	207
Nor 1	2	0.54	0.53	0.25	1.31	188	27	215
Nor 1	4	0.65	0.62	0.26	1.52	173	21	194
Nor 2	0	0.89	0.84	0.30	2.02	172	49	221
Nor 2	2	0.73	0.69	0.33	1.74	169	52	220
Nor 2	4	0.73	0.62	0.31	1.66	200	52	253
Nor 3	0	0.76	0.46	0.36	1.59	256	55	311
Nor 3	2	0.62	0.38	0.34	1.34	231	61	292
Nor 3	4	0.52	0.32	0.27	1.11	228	70	297
Nor 4	0	–	–	–	–	288	39	327
Spa 1	0	1.15	0.76	0.25	2.16	41	408	448
Spa 1	2	1.14	0.73	0.25	2.11	53	387	440
Spa 1	4	1.08	0.68	0.26	2.02	30	439	469
Spa 2	0	1.71	1.26	0.27	3.24	234	53	287
Spa 2	2	1.32	0.92	0.26	2.50	211	50	261
Spa 2	4	1.12	0.58	0.26	1.95	195	87	281
Spa 3	0	0.46	0.34	0.25	1.05	241	39	280
Spa 3	2	0.51	0.38	0.24	1.13	192	36	229
Spa 3	4	0.52	0.46	0.24	1.22	228	129	357
Spa 4	0	–	–	–	–	327	33	360

an equal content of fructose and glucose (in the range 0.86–1.03 g 100 g^{-1} FW each) and a minor content of sucrose (0.03 g 100g^{-1} FW) (Handley et al. 1983). Sucrose is metabolized into fructose and glucose in the cucumber fruit (McFeeters and Lovdal 1987). The decline of SSC, fructose and glucose during storage is in agreement with results from Japan, where a taste panel found that cucumbers that were stored at 5 or 10 °C for 10 days were less sweet, a result that correlated with a reduction in fructose and glucose content (Atsuko et al. 2002). A single estimation of sugar and acid distribution between outer mesocarp, mesocarp and endocarp revealed an increase in malic, citric, fructose and glucose concentrations inwards the cucumber fruit (data not shown). It should thus be expected that fruits with larger endocarp tissues would have more acids and sugars. An increase in fruit diameter from < 2.7 cm to 3.9–5.1 cm has previously been found to give a raise in total sugar content; from 1.75 to 2.40 g 100 g^{-1} FW (Lu et al. 2002). The present investigation found only weak correlations between fruit diameter or endocarp diameter and soluble solid content. In addition, these correlations changed during storage and require further investigation.

Total titratable acid (TTA) was found to increase during storage of the slicing cucumber (Table 1). There were also differences in TTA content between cucumbers from different producers. Cucumbers from Spain contained higher amounts of TTA, and an interaction was found between fruit origin and storage (Table 1, Table 2). A weak correlation between the diameter of the endocarp tissue and TTA was found (r = 0.41). Malic and citric were found to be the major organic acids in the cucumbers received in week 5 (Table 3). Malic made up 64 % in fresh cucumber and 57 % in fruit stored four weeks. The reason for this is an increase in citric acid rather than a reduction in malic acid content. Cucumbers from one producer (Spa 1) contained citric acid in quantities that resembled malic acid. The reason for this is unknown, but might in part be due to differences in growth- or transport conditions. We have no evidence to fully explain the observed increase in TTA and citric acid during storage. Similar observations have however been reported previously (Wang and Qi 1997). Cucumbers are susceptible to chilling injuries at temperatures < 10 °C (Cabrera and Saltveit 1990; Dhall 2013). Ahead of visible damages it has been demonstrated a 3C-carboxylic acid cycle disturbance in which citrate synthase activity decrease and pyruvate accumulate (Tsuchida et al. 2010). It might well be the case that cucumbers included in this investigation have been exposed to chilling temperatures during transport. A disturbed metabolism of organic acids might later occur at non-chilling temperatures (Cabrera and Saltveit 1990).

Results of the triangle test showed that there were detectable differences (P < 0.01) between the Norwegian and Spanish cucumbers (Table 4). Seventy-one percent of the panelists correctly identified the odd sample. This was a high number, since earlier experiments with cucumbers revealed no differences (Zhao et al. 2007). The paired preference test results showed an overall preference for the Spanish samples (Table 5). Nor 1,2,3 cucumbers were preferred by consumers in respectively 31 (43 %), 29 (39 %), 18 (25 %) of a total of 72 judgments, while Spa 1,2,3 were preferred in 35 (49 %), 58 (81 %), 45 (63 %) of a total of 72 judgments.

A significant positive correlation was found for consumer preference and SSC (r = 0.77), while a significant negative correlation was found for EC (r = −0.85). This might indicate that Norwegian consumers like cucumbers that are sweeter and less salty. Earlier experiments with tomato showed that Norwegian consumers like fruits with a high content of soluble solids (Verheul 2008). A

Table 4. Triangle test evaluation of the taste of fresh Norwegian (Nor 1 to 4) compared to Spanish (Spa 1 to 4) cucumbers received in week 5, 6 and 7 (2012) showing the number of correct responses and its significance (Iso 4120:2004) (number of judges: 24, total number of triangle tests: 240).

Comparison		Number of correct responses	Significance
Nor 1	Spa 1	17	***
Nor 1	Spa 2	15	**
Nor 1	Spa 3	18	***
Nor 2	Spa 1	20	***
Nor 2	Spa 2	15	**
Nor 2	Spa 3	15	**
Nor 3	Spa 1	19	***
Nor 3	Spa 2	17	***
Nor 3	Spa 3	15	**
Nor 4-organic	Spa 4-organic	18	***

***, **, *, NS: Significant at P < 0.001, P < 0.01,P < 0.05, or not significant, respectively

Table 5. Preference test results for fresh Norwegian (Nor 1 to 4) compared to Spanish (Spa 1 to 4) cucumbers received in week 5, 6 and 7 (2012) showing the number of judges with preference for Norwegian (Nor) or Spanish (Spa) cucumbers (number of judges: 24, total number of preference tests: 240).

Comparison		Preference Nor	Preference Spa
Nor 1	Spa 1	10	14
Nor 1	Spa 2	5	19
Nor 1	Spa 3	16	8
Nor 2	Spa 1	15	9
Nor 2	Spa 2	5	19
Nor 2	Spa 3	9	15
Nor 3	Spa 1	12	12
Nor 3	Spa 2	4	20
Nor 3	Spa 3	2	22
Nor 4-organic	Spa 4-organic	5	19
Sum		83	157

weak negative correlation was found between consumers preference and TTA (r = −0.45). No significant correlations were found between consumer preference and fruit firmness.

A good correlation was found between consumers preference and SSC/TTA (r = 0.84) or SSC/EC (r = 0.88). The SSC/TTA ratio is often used to describe flavor quality of fresh market tomato (Malundo et al. 1995). Interestingly a high correlation was found between consumer preference and $SSC^2 \times (TTA \times EC)^{-1}$ (r = 0.96). This indicates that consumer preference for cucumbers might be predicted by measurements of SSC, TTA and EC. However, this relationship applies only for the ranges of SSC (2.7–3.6° Brix), EC (3.5–4.3 mS cm^{-1}) and TTA (65–126 mg CAE 100 g^{-1} juice) found in fresh slicing cucumbers in the present experiment. A more expanded experiment should be performed to establish more extensive relations between the given parameters.

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