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Who's to Blame for Tasteless Tomatoes? The Effect of Tomato Chilling on Consumers' Taste Perceptions

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Summary

The most common stated reason to consumer dissatisfaction with tomatoes is lack of flavour. It has been shown that a common storage practice among consumer households is to store tomatoes in the refrigerator, which have a negative impact on tomato taste. Thus, consumer postharvest treatment in home may be a reason to diminishing taste. In a Swedish consumer survey we find that 53 % are dissatisfied with tomato taste and that 74 % store their tomatoes after purchase in a temperature below recommendations. Research done on the effect of tomato storage has led to the suggestion that growers should educate consumers on handling practices in order to remove the negative effect chilling has on taste experience. However, past research has been conducted on samples that potentially do not represent the target consumer, as trained sensory panels do not perceive taste as untrained consumers do. Based on previous empirical studies using expert panels, we hypothesise that panels consisting of ordinary consumers will prefer tomatoes stored in room temperature to those chilled under ordinary refrigerated conditions (i.e. 7 °C) regardless of variety. Thus, we replicate and challenge past findings and normative recommendations through the use of two experiments involving consumer panels evaluating two varieties of tomatoes, 'Arvento' and 'Tiësto', stored two days in refrigerator (7 °C) and room temperature (21 °C) respectively. We found a significant difference in consumer liking for 'Arvento' that were unchilled (M=6.443, SD=±1.765) and chilled (M=5.849, SD=±1.894), t(351)=4.270, p<0.001 (two tailed), albeit with a small effect size (eta squared statistic (.049)). No significant difference in liking was found for the 'Tiësto' variety. We find, contrary to previous research, that storage temperature has no or only a marginal effect on perceived taste among respondents in untrained consumer panels for the two varieties in our trial. Theoretical and practical implications are discussed.

Key words. *Lycopersicon esculentum* – consumer panel – consumer acceptance – storage temperature – taste – horticultural marketing

Introduction

Could tomatoes be "losing" their taste and if so, who is to blame? Taste loss in fresh market tomatoes (*Lycopersicon esculentum* Mill.) has grabbed consumer attention in part by media highlighting industry practices that enable big and beautiful, albeit watery tasting modern tomatoes also known to German consumers as "Dutch Wasserbombe" (Estabrook 2011). The hyperbole surrounding tomato taste appears genuine as consumers are relatively displeased with quality and taste (Bruhn et al. 1991; Parks and Newman 2005). Researchers have also taken note and are investigating the facts and reasons behind the unwanted, but perhaps warranted attention towards tomato taste. Some of the reasons mentioned include the diminished importance and prioritization of taste in the modern production system extending throughout the value chain with a focus on high yields, disease resistance, highly uniform products, high durability, resistance to rough treatment and a low end price, rather than on taste (Hobson 1988; Baldwin et al. 1998; Friedland 2006; Hongsoongnern and Chambers 2008; Estabrook 2011; Ekelund and Jönsson 2011).

Tomato taste is complex as it comprises several components, including reducing sugars, free acids, minerals, amino acids and more than 400 identified volatile substances (Petro-Turza 1987). Various direct, mediating and moderating factors have been found to affect the taste of tomatoes, such as the properties of different tomato varieties (Verkerke et al. 1998; Baldwin et al.

1998; Serrano-Megías and López-Nicolás 2006; Causse et al. 2010; Ross et al. 2010), growing method (Zhao et al. 2007), the use of fertilizers (Heeb 2005; Heeb et al. 2006), salinity treatment (Mizrahi 1982), maturity stage at harvest (Watada and Aulenbach 1979), and storage period (Kader et al. 1978; Auerswald et al. 1999; Krumbein et al. 2004). Looking at the effect of storage temperature on tomato quality, it has been shown that flavour and aroma are affected by temperatures below 12.5 °C (Maul et al. 2000). Concentrations of volatiles decrease under chilled conditions (Buttery et al. 1987; Stern et al. 1994) and sugar levels decrease (Kader et al. 1978; Farneti et al. 2010) while acid contents increase at lower temperatures (Farneti et al. 2010). These are indications that refrigeration leads to a loss of sensoric quality and taste in particular.

Improper temperature treatment in the distribution chain, in store, or consumers' homes may be a reason behind loss of taste in tomatoes and reported consumer dissatisfaction. Bruhn et al. (1991) showed that around half of American consumers refrigerate their tomatoes at home, while in the same study 40 % were dissatisfied with quality. Parks and Newman (2005) similarly showed that 70 % of Australian consumers stored their tomatoes chilled, while 57 % felt that tomato flavour was poor. The average refrigerator temperature in Swedish households is between 4 and 8 °C, and 60 % of Swedish consumers maintain a temperature of between 6 and 10 °C (Konsumentföreningen Stockholm 2011). This is well below the recommended (11 to 14 °C) storage temperature for tomatoes given by the National Food Agency (Livsmedelssverige 2009). Ironically, part of the problem with consumer dissatisfaction with "tasteless" tomatoes may be the consumers' own post-purchase handling and storage practices.

Studies using trained expert panels have shown that different storage treatments have an effect on taste (Kader et al. 1978; Maul et al. 2000). These and similar findings have led to the suggestion that consumers should be given education on proper tomato storage techniques (Sommer et al. 1979; Bruhn et al. 1991). However, educating consumers is a tricky if not expensive proposition; worse, it may be ill-advised if the benefits do not exceed the costs. While we know something about chilling effects on taste using trained expert panels, we lack a similar understanding of ordinary consumers. According to Hersleth et al. (2005) there are important differences between trained and ordinary consumer panels; the former are calibrated and trained for conducting descriptive tasks, while the later evaluates hedonically and uses subjective criteria. Consequently, Hersleth et al. (2005) suggest the possibility that these groups have different taste preferences. While we do not look for or suspect trained panels and ordinary consumers store their tomatoes differently, consumer habits change over time and a recent snap-shot view of them will help us to understand the contribution of storage habit on the overall taste problem.

With this background, the objectives in this study are to describe cross-sectionally consumers' post-harvest treatment at home and to test the effect of temperature on taste perception. Based on previous empirical studies using expert panels, we hypothesise that panels consisting of ordinary consumers will prefer tomatoes stored in room temperature to those chilled under ordinary refrigerated conditions (i.e. 7 °C) regardless of variety.

Material and Methods

A consumer survey on consumers' handling procedures at home was combined with data from a within-group experiment where consumers evaluated chilled and unchilled (stored in room temperature) tomatoes. The experimental conditions were varied using the most commonly grown commercial variety of tomato in Sweden during 2010, 'Arvento', and another less common variety, 'Tiësto'. The tomatoes were harvested at red ripening stage according to USDA classification (U.S.D.A. 1975). The tomato variety 'Arvento' (Rijk Zwaan Seeds) were collected directly from a Swedish grower (Assarsson Trädgård AB, Motala) and half of them stored at 7 °C, representing an ordinary household refrigerator temperature, and the other half at room temperature (21 °C) for 48 h before serving (all tomatoes were served at red ripening stage). Shortly before serving, the chilled tomatoes were taken into room temperature, so that serving temperature was the same for both varieties. The tomatoes were each cut in 12 slices (intended for four servings per tomato) and served on paper plates marked × and y. The consumers were asked to indicate their judgement of the tomatoes on a 9-point Likert Scale labelled "not at all tasty" to "very tasty", following the method described by Lawless and Heymann (2010). The second experiment followed the same design using tomatoes of the variety 'Tiësto' (De Ruiter Seeeds) collected from another grower in Southern Sweden (Vikentomater, Viken).

Except for demographic data, the questions pertaining to this study were: a) "How do you store your tomatoes at home (three categorical alternatives)?"; b) "If you have been dissatisfied with the tomatoes you have bought, what are the most common reasons (the respondents could select up to three choices from eight categorical alternatives and had the possibility to add other)?"; c) "How often do you eat tomatoes (four categorical values)?"; d) "How often do you purchase tomatoes (four categorical values)?". The categorical alternatives are shown in the results section. The questions were originally in Swedish and translated to English for reporting purposes.

The survey and taste assessment with the variety 'Arvento' took place in the cities of Linköping and Norrköping and was conducted with 364 respondents and the assessment with the variety 'Tiësto' in Helsingborg had 103 respondents. In all cases volunteers participated in the study without any form of payment and three Swedish

shopping centres were the locations for the activities. The survey questions were the same in all cases. Shopping centres and supermarkets have similarly been used for taste assessments and consumer surveys (Collins et al. 1990; Lusk et al. 2001; Luckow and Delahunty 2004) and it has been shown that the choice of environment for consumer testing and degree of social interaction in consumer taste assessments have no effect on hedonic rating of the products (Hersleth et al. 2004).

The data were analysed using descriptive statistics with regard to the survey and paired-samples t-tests concerning the taste assessments using SPSS.

Results

Consumer survey

In total, 467 consumers with a mean age of 46.5 years and a gender distribution of 60 % female and 40 % male participated in the study. 76 % eat tomatoes three times a week or more, 17 % once or twice a week and seven percent more seldom, while 83 % of all respondents bought tomatoes at least once a week. The most common in home storage method was the refrigerator at 54 % of the sample (≤8 °C); in 20 % of the cases in a pantry (approximately 10–12 °C) and 26 % stored them in room temperature (circa 20 °C).

396 of the respondents received the question "if you are dissatisfied with the quality of the tomatoes you buy, what attributes are you dissatisfied with" (not all respondents received this question in the first distributed questionnaire)? The respondents could mark three alternatives from a list of eight common attributes (too little flavour, too hard, too soft, too grainy texture, over-ripe, they never ripen, bad appearance and too expensive) and had the possibility to answer "other". 66 % indicated that they sometimes were dissatisfied with the quality and the most stated reason was "too little flavour", stated by 53 % of the 396 respondents, followed by "too soft tomatoes" (31 %) and "too expensive" (20 %) (see Fig. 1).

Taste assessment

In the taste assessments we received 352 completed questionnaires in the 'Arvento' variety experiment and 101 for 'Tiësto'. Incomplete questionnaires when it comes to the dependent variable (i.e. the respondent did not answer or only graded the taste of one of the two tomatoes) was excluded.

In order to test our hypothesis, a paired-samples t-test was conducted to evaluate the impact of a tomato being chilled or unchilled on taste. In the first experiment there was a statistically significant difference on taste between tomatoes of the variety 'Arvento' that were unchilled (M=6.443, SD=±1.765) and chilled (M=5.849, SD=±1.894), $t(351)=4.270$, $p<0.001$ (two tailed) (Fig. 2). Compared with unchilled tomatoes, there was a mean decrease in reported liking for chilled tomatoes (mean value = 0.594) with a 95 % confidence interval ranging from 0.320 to 0.867. The eta squared statistic (.049) indicated a small effect size (Cohen 1988). The first experiment supported our hypothesis that chilled tomatoes were, statistically speaking, significantly less tasty than those previously unchilled. However, given the small effect size the difference in taste appears marginal.

In the second experiment, the hypothesis was replicated by once again conducting a paired samples t-test. The data indicates that there is no significant difference between the tomatoes of the variety 'Tiësto' that were unchilled (M=6.287, SD=±1.796) and chilled (M=6.366, SD=±1.617), $t(100)=-0.328$ (see Fig. 2).

Discussion

The results from our consumer survey showed that 53 % claimed "too little flavour" to be the main reason for

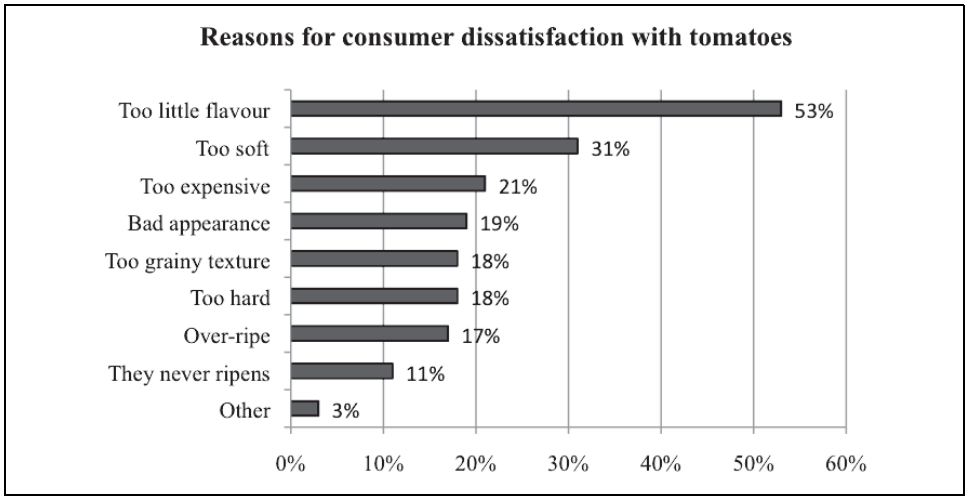


Fig. 1. Most common reasons for consumer dissatisfaction with tomatoes. Up to three alternatives could be marked (including the possibility to note other not pre-given alternative), thus the total percentage exceeds 100 %. Consumer panel N=396.

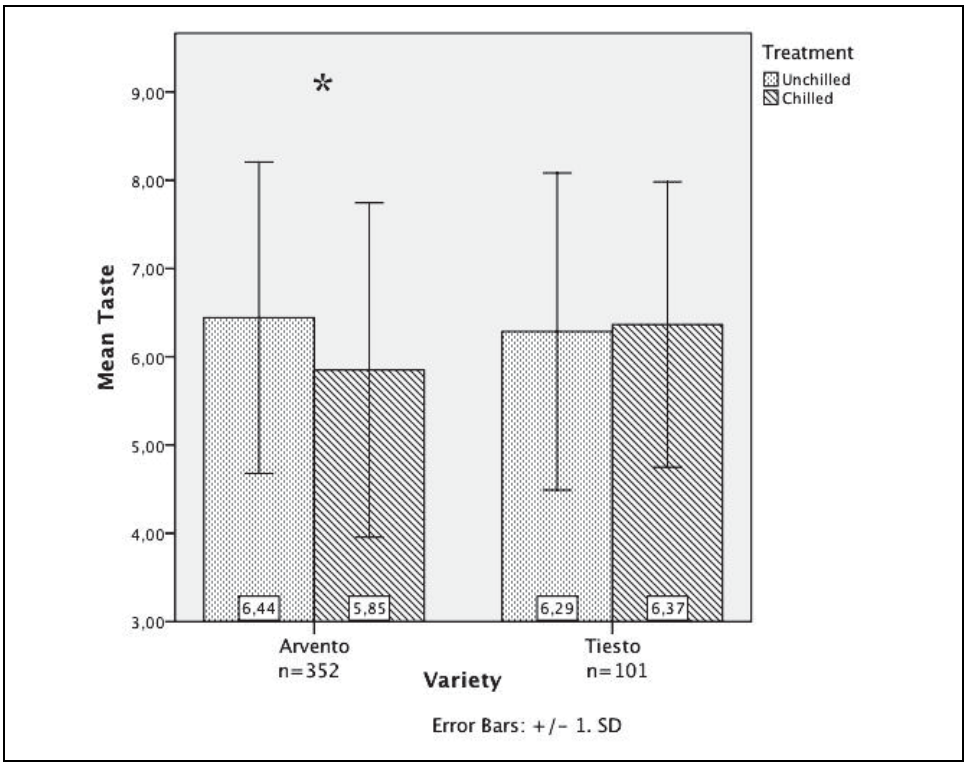


Fig. 2. Consumer evaluation of two varieties of tomato being unchilled or chilled. Mean values from consumer assessment, grades given on a hedonic scale where 1=less taste and 9=very tasty. * Indicates a significant difference ($p<0.001$) in pairwise samples t-test, $\eta^2=.049$.

dissatisfaction. Bruhn et al. (1991) found similar results where 48 % claimed "little flavour" to be the most common reason for dissatisfaction and Parks and Newman (2005) showed that 57 % felt that tomato flavour was poor. This is well in line with what other sources discuss as the main quality issues with the modern tomato (Hobson 1988; Baldwin et al. 1998; Friedland 2006; Estabrook 2011; Ekelund and Jönsson 2011). The respondents (54 %) stored their tomatoes in refrigerators below 8 °C, and another 20 % in a pantry with storage temperatures below 12 °C, while 26 % stored them in room temperature. This indicates that potentially three of four respondents store their tomatoes in a way that, according to the literature, might affect tomato taste negatively. If taste is indeed harmed by "improper" storage habits as prior literature suggests we would expect to find significant and meaningful differences in the experiments we conducted.

In the first taste assessment we found support for our hypothesis with a significant difference in taste; people seemed to prefer 'Arvento' tomatoes that were never chilled to those that were chilled. However we also analysed how meaningful or substantive this significant difference was. Based on the small effect size we found it appears as though the difference in taste was also small. To corroborate this finding, we looked at another variety of tomato, 'Tiësto'. Surprisingly, we found no support for our hypothesis when it was applied to the 'Tiësto' variety.

Previous studies (Sommer et al. 1979; Bruhn et al. 1991) suggest that consumers should be better informed on how to store tomatoes in home. Maul et al. (2000) suggest that short-term storage of ripe tomatoes at typical household refrigerator temperatures could be a contributing factor to consumer complaints. Based on the findings in our study, the importance of consumer post-harvest treatment in home and the effect of chilling on tomatoes may be overstated as consumers perceive at best only small changes in taste. Furthermore, the issue of whether the consumer is responsible is less clear. Our findings, showing only a small effect size on the 'Arvento' variety and no significant effect on the 'Tiësto' variety in taste change after chilling, indicates there are other, more important reasons outside of the consumer's control for taste dissatisfaction which should be addressed. Thus, costly programs of informing and educating consumers about post-harvest treatment in home may add needlessly to costs and deliver only marginal results. Arguably, these monies and attention would be better spent earlier in the chain to address product related issues such as stage of ripeness or those brought up in our consumer survey such as the tomato being "too soft" or unattractive in appearance.

It is important to put these findings in context. The tomatoes we studied were only stored for two days which limits the generalizability of the findings. Parks and Newman (2005) showed that a majority of Australian consumers store their tomatoes for longer than two days. Moreover, Farneti et al. (2010) indicates consumers often store tomatoes for longer periods, which may lead to taste degradation. Further studies that test the effects on taste of various storage periods seem warranted.

In the case of the two tested varieties in our experiments, the variety 'Arvento' is still widely grown in Swedish greenhouses with acceptable experienced quality and seen among growers to have stable quality properties, while the 'Tiësto' variety is no longer in commercial production as it has not met growers' expectations (Christensen 2011). As seen in Swedish consumer statistics, the demand for speciality tomatoes is increasing. Cocktail varieties, plum tomatoes, organic tomatoes and tomatoes 'on-the-vine' have gained market share at the expense of the single round tomato which now occupies approximately 60 % of the Swedish market (GfK Sverige 2010). Consumers' dissatisfaction with taste concerning the single round tomato might be a reason for switching to specialty tomatoes. However, given the widespread habit of refrigerated storage, other options may be explored. One interesting, yet unexplored avenue might be to investigate the effects of storage temperature on different varieties of tomatoes and consumers sensory experiences to see which if any tomato varieties are robust to the effects of chilling. Studies of this nature are sure to attract the attention of producers, especially given recent findings from Farneti et al. (2010) that show home storage conditions (at 4 °C) negatively affect tomato quality and possibly sensoric quality. Also, studying the storage temperatures throughout the distribution chain would be of importance, as we know little about temperature fluctuations on the tomato's way from greenhouse to consumers' shopping baskets.

The results have practical implication for tomato growers, as well as for actors throughout the distribution chain and the end consumer. Much of the received wisdom advocates informing consumers about the importance of proper post-harvest treatment (i.e. room temperature storage) on ensuring the best taste experience possible. However the evidence presented here is that although chilling might affect taste, it may not do so to the extent reported by previous studies involving chemical analyses and trained expert panels. The effects of chilling may have been overestimated when it comes to the actual experience by ordinary consumers. That said, we tested previously chilled and unchilled tomatoes eaten in room temperature. It may be the case that a greater effect can be found when the tomato is eaten whilst cold instead of at room temperature. Further research of temperature effects on tomato taste should take this into account as well as test the effects on a wider range of varieties. Doing so should give the tomato industry useful insights on variety selection and improve "real world" tomato experience.

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