Tomato Flavor and Plant Nutrition: A Brief Review

By R.L. Mikkelsen

Why don't most tomatoes purchased in grocery stores have that same great flavor of vine-ripened tomatoes straight from the backyard garden? The answer is not simple. Here's a summary of information that helps explain the situation.

Much concern has been expressed regarding the perceived low quality of tomatoes available in the consumer market. Some of the blame has been laid on modern tomato varieties, but the degree of ripeness also has an effect. Packing houses commonly expose tomatoes to supplemental ethylene gas (a natural hormone produced by many types of fruit) in order to accelerate the ripening process. Commercial tomatoes are frequently selected for disease and pest resistance or growing season restrictions that are best served by a particular hybrid. Cultural practices such as picking fruit before it is vine ripened also can have negative effects on taste and quality.

For the home vegetable grower, taste is probably the most important concern. Commercial growers have many other concerns involved with successfully producing and marketing their crop, in addition to taste. The effects of phosphorus (P), potassium (K), and other nutrients are generally positive on fruit quality, although some benefits have not been carefully studied.

Tomato Flavor and Degree of Ripeness

Assessing tomato flavor is not a simple matter. The intensity of flavor properties of tomato fruits is determined largely by the amount of **sugar** (primarily fructose and glucose), the **organic acid** content (primarily citric, malic, and total acidity), and the **volatile compound** composition. Typically, human taste panels find best flavor associated with high soluble solids and soluble solids/titrateable acidity ratios. **High sugar and high acid contents generally have a favorable effect on taste.**

Differences between the flavors of varieties…and the weaker flavor of greenhouse-grown or artificially ripened tomatoes…are explained by the different quantitative proportions of the volatile substances. Of the environmental factors, light has the most profound effect on the fruit sugar concentration. Generally, more sunlight reaching the fruit results in higher sugar content. As a consequence, greenhouse tomatoes grown during the winter months contain substantially less sugar than field-grown tomatoes in the summer.

The characteristic tomato flavor is influenced by many volatile substances, many of which develop during ripening. Kadar (1977) reported that tomatoes picked at under-ripe stages were less sweet, more sour, less "tomato like", and had more off-flavor than those picked at the table-ripe state. The development of long-chain carbonyls and terpene esters that occurs during the ripening stage is essential for the typical tomato aroma.

Effects of P and K on Tomato Quality

Several studies have directly or indirectly examined the effect of plant nutrition on tomatoes, which are briefly reviewed here. Of the mineral nutrients, K…by influencing the free acid content…and P…due to its buffering capacity…directly affect tomato quality.

Tomatoes receiving standard nutrition (100%) were compared with enhanced nutrition (150%). The enhanced nutrition treatment was found to have a significant positive effect on tomato quality, color, and acceptability (Kimball and Mitchell, 1981). Other studies have also shown that K and P nutrition has a positive effect on fruit sugar and acid content (Lacatus et al., 1994). Of the nutrition factors, the soil K content most affects the total acid content in the fruit. Davies and Winsor (1967) found a positive logarithmic correlation between the K level in the soil and the acid content of the fruit. However, Wright and Harris (1985) reported that increased nitrogen (N) and K fertilization had a detrimental effect on tomato flavor, as scored by a taste panel (although increased acidity and soluble solid content resulted from increasing fertilization).

The development of red color in tomato fruit during ripening is mainly due to the synthesis of various carotenoid pigments, particularly lycopene. The lack of uniform coloration is a common ripening disorder, often referred to as "blotchy ripening" and "yellow shoulder." Trudel and Ozbun (1971) used sand culture to grow tomatoes with various K concentrations in the nutrient solution. They found that the K content of both fruit and petiole increased with increasing concentration of K in the sand culture. Total carotenoids in the fruit generally increased with increasing amounts of K and the lycopene content rose as the K level increased.

Processing tomatoes have a high K requirement. Crop uptake can exceed 350 lb K/A, the majority of which is removed in the fruit. Uniform fruit color is important for this industry. Lachover (1972) reported that K fertilization increased fruit yield and solid content, even in soils with high K availability. The incidence of both internal and external blotchy ripening was generally decreased with increased K supply. Hartz et al. (2001) conducted a field survey looking at yield and color under a variety of K fertilization practices for processing tomatoes. Results suggested that current soil K recommendations be adjusted upwards for maximum fruit yield, and that optimizing fruit color uniformity may require a greater soil K supply than needed for maximum fruit yield.

Summary

There are many complex factors that determine the flavor and quality of tomato fruit. Commercial fresh tomato production is not always geared to produce the most flavorful fruit, since other economic concerns must also be considered. In addition to primary factors (such as tomato variety selection, degree of ripeness during picking, and growing conditions), proper plant nutrition will also positively contribute to tomato flavor and appearance. BC

Dr. Mikkelsen is PPI West Region Director, Davis, California; e-mail: rmikkelsen@ppi-far.org.

Selected References

Davies, J.N., and G.W. Winsor. 1967. Effect of nitrogen, phosphorus, potassium, magnesium and liming on the composition of tomato fruit. J. Sci Food Agric. 18:459-466.

Hartz, T.K., E.M. Miyao, R.J. Mullen, and M.D. Cahn. 2001. Potassium fertilization effects on processing tomato yield and fruit quality. Acta Hort 542:127-133.

Kadar, A.A., M.A. Stevens, M. Albright-Holton, L. Morris, and M. Algazi. 1977. Effect of fruit ripemess when picked on flavor and composition in fresh market tomatoes. J. Amer. Soc. Hort. Sci. 102:724-731.

Kimball, B.A., and S.T. Mitchell. 1981. Effects of CO_2 enrichment, ventilation, and nutrient concentration on the flavor and vitamin content of tomato fruit. HortScience 16:665-666.

Lacatus, V., C. Botez, M. Chelu, R. Mirghis, and V. Voican. 1994. The influence of organic and mineral fertilizers on tomato quality for processing. Acta Hort 276:329-332.

Lachover, D. 1972. The effect of potassium on a 'Roma' variety of processing tomato with special reference to potassium uptake, yield and quality. Qual. Plant Mater. Veg 21 (3):165-177.

Petro-Turza, M. 1987. Flavor of tomato and tomato products. Food Review International 2:309-351.

Trudel, M.J. and J.L. Ozbun. 1971. Influence of potassium on carotenoid content of tomato fruit. J. Amer. Soc. Hort. Sci. 96:763-765.

Wright, D.H., and N.D. Harris. 1985. Effect of nitrogen and potassium fertilization on tomato flavor. J Agric. Food Chem. 33:355-358.