Relationship between Pyruvate Analysis and Flavor Perception for Onion Pungency Determination

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Abstract. Individual onion (*Allium cepa* L.) bulbs were evaluated for pungency by measurement of enzymatically produced pyruvate and by flavor perception. In four separate experiments, pyruvate values were highly and significantly correlated to mean sensory ratings. Correlation coefficients (r) were 0.92, 0.84, 0.95, and 0.79, and regression coefficients (R^2) were 0.84, 0.71, 0.91, and 0.62. The high correlations indicate that pyruvate analysis can be used as a reliable selection technique for pungency in onion breeding programs.

Onion pungency develops when the enzyme allinase hydrolyzes the flavor precursors S-alk(en)yl cysteine sulfoxides during tissue bruising or maceration. The reaction products are pyruvate, ammonia, and the many volatile sulfur compounds characteristic of onion flavor and aroma (Carson and Wong, 1961; Lancaster and Boland, 1990; Schwimmer and Weston, 1961). Onion flavor can be determined by measurements of flavor precursors, reaction products, or allinase activity. All methods have advantages and drawbacks, and these are reviewed by Lancaster and Boland (1990). Ultimately, any biochemical flavor analysis must be highly correlated with sensory perceptions for the technique to be useful.

Measurement of pyruvate, a reaction product, is most promising for selection of low- or high-pungency onions in breeding programs. Relative to measuring the volatile flavor components directly, the pyruvate method is rapid and can be used to screen many samples (Lancaster and Boland, 1990).

Pyruvate analysis measures total pungency but does not estimate the relative amounts of individual flavor precursors or

final flavor volatiles. The pyruvate technique was highly correlated ($r = 0.97$) with olfactory threshold concentrations of onion juice in a study by Schwimmer and Guadagni (1962). The threshold concentration was defined as the minimum concentration (parts per million) of onion juice in water that could be detected by smell by 70% of the judges. However, pungency evaluation by smell alone may not accurately reflect the pungency that would be perceived by tasting. Aromatic compounds may be perceived as more potent by tasting than by smelling, because samples' aromatic constituents become more volatile when warmed by the mouth (Jellinek, 1985).

To our knowledge, pyruvate analysis has not been compared with sensory perception by a taste panel, a necessary demonstration if pyruvate measurements are to be used as a reliable selection criterion for pungency in a breeding program. The objectives of this research were to examine the relationship between pyruvate analysis and flavor perception of individual onion bulbs and to determine whether the correlation between the methods is sufficiently high to use pyruvate analysis as a criterion for pungency selection.

Pyruvate analysis was performed according to Schwimmer and Weston (1961) with modifications. Dry outer scales were removed, and bulbs were cut in half equatorially. Top portions were used for pyruvate measurements, and bottom portions were retained for taste testing. A control wedge was removed from the top portion of each bulb, and 20 g of tissue was quickly sliced into 60 ml of 5% trichloroacetic acid to inactivate the allinase enzyme for background mea-

surement of pyruvate levels. After 1 h, controls were blended for 3 min and filtered. Control filtrates were diluted (1:10) with distilled H₂O and analyzed for pyruvate. Sample wedges were blended with an equal volume of distilled H₂O for 3 min, allowed to sit covered for 15 min, filtered, and diluted in distilled water (1:20). Each reaction test tube contained 1 ml of diluted filtrate, 1 ml of distilled H₂O, and 1 ml of 2,4-dinitrophenylhydrazine (0.0125% DNPH in 2 N HCl). A blank was prepared with 2 ml H₂O and 1 ml DNPH. All reaction tubes were vortexed and placed in a water bath (37°C) for 10 min. After the incubation period, 5 ml of 0.6 N NaOH was added, and test tubes were vortexed and let stand for 5 min. Pyruvate was measured using a spectrophotometer (Sequoia-Turner Model 690; Mountain View, Calif.) at 420 nm for both control and sample filtrates. Standards were prepared with sodium pyruvate. Final pyruvate concentration per bulb (micromoles per grams fresh weight) was calculated from the difference between pyruvate levels in the sample and control wedges.

In 1990, a preliminary taste test was performed with a trained panel of four people. Two bulbs were randomly sampled from each of five cultivars or breeding lines in an effort to include bulbs from a range of pungency classes. The 10 bulbs were individually analyzed for pyruvate levels in the morning and retained for taste testing the same afternoon. Each person tasted each bulb twice in random order and rated the bulbs for relative pungency based on a scale where 1 = extremely mild, 3 = slightly pungent, 5 = moderately pungent, 7 = pungent, and 9 = extremely pungent.

In 1991, taste tests were modified to include fewer bulbs, a larger taste panel, and

Fig. 1. Relationship between flavor perception and pyruvate analysis of onion pungency in 1990, $r = 0.92$, $R^2 = 0.84$, $Y = -4.230 + 1.683x$. Correlation and regression coefficients are significantly different from zero ($P < 0.05$). Flavor rating scale: 1 = extremely mild, 3 = slightly pungent, 5 = moderately pungent, 7 = pungent, and 9 = extremely pungent.

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Fig. 2. Relationship between flavor perception and pyruvate analysis of onion pungency for three experiments in 1991. (A) Experiment 1, $r = 0.84$, $R^2 = 0.71$, $Y = -3.304 + 1.137x$. (B) Experiment 2, $r = 0.95$, $R^2 = 0.91$, $Y = -1.345 + 0.981x$. (C) Experiment 3, $r = 0.79$, $R^2 = 0.62$, $Y = -1.494 + 0.926x$. Correlation and regression coefficients are significantly different from zero ($P < 0.05$). Flavor rating scale: 1 = extremely mild, 2 = mild, 3 = slightly pungent, 4 = pungent, and 5 = extremely pungent.

an adjusted rating scale. Six bulbs were analyzed for pyruvate in the morning and randomly sampled by a trained panel of eight people in the afternoon. The bulbs were from six cultivars or breeding lines. A rating scale was used where 1 = extremely mild, 2 = mild, 3 = slightly pungent, 4 = pungent, and 5 = extremely pungent. The panel was instructed to taste all of the scales (inner, middle, outer) for each sample and to clear their palates with water, crackers, and apple slices between samples. The experiment was repeated three times on different days with new sets of bulbs. Mean taste ratings for individual bulbs were calculated, then compared with pyruvate values using correlation and regression analysis. Each experiment was analyzed separately.

Mean taste perception ratings were highly and significantly correlated with pyruvate values for each experiment. In 1990, the correlation coefficient (r) was 0.92 (Fig. 1). In 1991, the correlation coefficients were 0.84, 0.95, and 0.79 for the three experiments (Fig. 2). These values are quite high, considering the inherent difficulty in conducting an onion taste test, namely recruiting and training panel members, and controlling the variability associated with human sensory perception. Also, tasting a highly pungent onion requires a long wait to clear the palate before tasting the next sample. For these reasons, the number of samples was decreased from 10 to six bulbs

in 1991 and the number of panel members was doubled.

The high correlations between flavor perception and enzymatically produced pyruvate demonstrate that pyruvate analysis is a useful method for measuring onion pungency. Whether small differences in pyruvate values denote genetic differences still needs to be studied. If less variability is associated with pyruvate analysis than with taste panel ratings, the pyruvate technique will be a more efficient selection criterion than taste perception. Also, pyruvate analysis would be less expensive and more objective than taste tests for evaluations of several hundred bulbs.

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