Investigating key determinants of potato flavour and texture

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Background

Sensory traits such as flavour and texture are important factors in consumer preference trials. In order to improve germplasm it is important to increase our understanding of the molecular basis of these traits.

Our studies were based on the comparison of Phureja with Tuberosum tubers. Phureja tubers not only score higher in professional sensory evaluation panels but they also cook more quickly than Tuberosum tubers. This led us to make comparisons of flavour metabolites from boiled tubers from a range of Phureja and Tuberosum cultivars and investigate differences in tuber texture.

Aims of the project

Understand the factors that contribute to tuber flavour and texture by comparing different potato germplasm.

Exploit this knowledge to understand the metabolic pathways responsible for these traits in order to pinpoint target genes.

Results

Matrix associated umami compounds

The non-volatile matrix associated umami compounds enhance flavour and mouth feel. The major umami compounds present in potato tubers are the amino acids, glutamate and aspartate and the 5' ribonucleotides, GMP and AMP. The synergistic effect between certain free amino acids and 5'-ribonucleotides can be measured using an equivalent umami calculation (EUC). Previous studies at SCRI have shown that Phureja tubers contain significantly higher levels of umami compounds compared to Tuberosum correlating strongly with acceptability scores from sensory evaluation data[1].

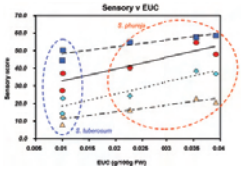


Figure 1. *S. tuberosum* cultivars Maris Piper and Record were compared with *S. phureja* clones DB333-16 and DB257-28, and cultivar Mayan Gold. Square, flavour intensity; circle, acceptability; diamond, flavour sweet; triangle, flavour creamy.

Effect of different storage regimes on tuber umami content

- Umami compounds were compared in Phureja and Tuberosum tubers during storage at 4 and 10°C.
- EUC values are significantly higher in Phureja cultivars compared with Tuberosum cultivars at harvest.
- However, after three months of storage at 4°C and 10°C, there was no significant difference in the EUC values for the Phureja and Tuberosum tubers.

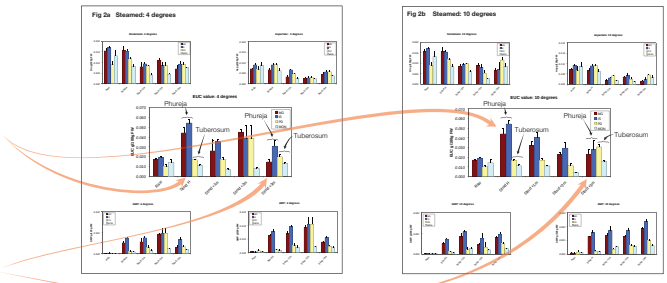


Figure 2a and 2b. Effect of tuber storage regime on umami amino acids, 5'-ribonucleotides and equivalent umami concentrations (EUC) in cooked potato cultivars Mayan Gold (MG), Inca Sun (IS), Pentland Dell (PD) and Montrose (MON). Tubers were sampled at harvest (H) and after 1, 2 and 3 months storage at 4°C and 10°C

Volatile taste metabolites

A major difference in the cooked tuber flavour volatile profile is the higher level of the sesquiterpene compound alpha-copaene in Phureja compared with Tuberosum. A sesquiterpene synthase gene was identified as being more highly expressed in Phureja tubers by microarray analysis[2]. This result was confirmed by qRT-PCR analysis.

Tuber-specific over-expression of the cloned sequiterpene synthase cDNA in Tuberosum leads to the accumulation of alpha-copaene with the best line showing a 13-fold increase compared to WT levels.

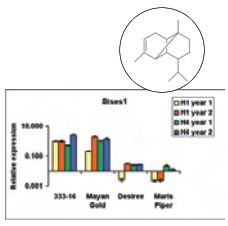
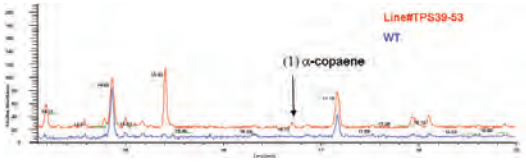


Figure 3. Sesquiterpene synthase (*stses1*) gene expression profile in Phureja (333-16, Mayan Gold) and Tuberosum (Desiree, Maris Piper) cultivars during tuberisation (harvest stages H1 = developing tuber, H4 = mature tuber).

Figure 4. GC-MS analysis of extracts of wild type and sesquiterpene synthase transgenic potato lines.



Texture related gene expression analysis

Major differences in the expression levels of genes involved in cell wall biosynthesis (and potentially texture) were also identified by microarray analysis including genes encoding pectin methylesterase and pectin acetylesterase. Quantitative PCR assays were performed to confirm the microarray expression patterns.

Enzyme activity of pectin methylesterase was measured using an in-gel enzyme assay. PME activity was consistently higher in Tuberosum compared with Phureja.

Transgenic plants overexpressing the PME gene exhibit a firmer texture compared to wild type controls whereas antisense lines had a softer texture.

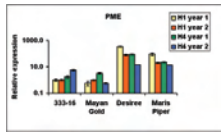


Figure 5. Expression profile of pectin methylesterase (PME) Phureja (333-16, Mayan Gold) and Tuberosum (Desiree, Maris Piper) cultivars during tuberisation (harvest stages H1 & H4).

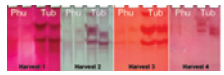


Figure 6. PME activity gels. Gels were loaded with equal protein and incubated with apple pectin prior to staining with Ruthenium red (binds unmethylated pectin). Darker bands indicate higher methyl esterase activity. Phu, Phureja; Tub, Tuberosum.

Texture analyzer

Tissue culture of transgenics

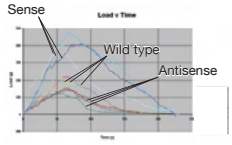


Figure 7.
Texture comparisons of wild type and PME transgenic plants.

Summary

Significant and consistent differences in both non-volatile and volatile components were detected and we hypothesise that these compounds underpin the preferred flavour of Phureja. We are currently aiming to understand the metabolic pathways by which these compounds are made in order to pinpoint target genes.

Major differences in the expression levels of genes involved in pectin modification were also identified and are currently being tested by transgenesis. A genetic approach is currently being used to identify quantitative trait loci (QTL) associated with tuber quality.

References

1) Morris W.L., Ross H.A., Ducreux L.J.M., Bradshaw J.E., Bryan G.B., and Taylor M.A. **2007**. Umami compounds are a determinant of the flavor of potato (Solanum tuberosum L.). *Journal of Agricultural and Food Chemistry* 55, 9627-9633.

2) Ducreux L.J.M., Morris W.L., Prosser I. M., Morris J.A., Beale M.H., Wright F., Shepherd T., Bryan G.B., Hedley P.E., and Taylor M.A. **2008**. Expression profiling of potato germplasm differentiated in quality traits leads to the identification of candidate flavour and texture genes. *Journal of Experimental Botany* 59, 4219-4231.

Acknowledgements

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