Understanding the causes and consequences of high-carotene cassava roots

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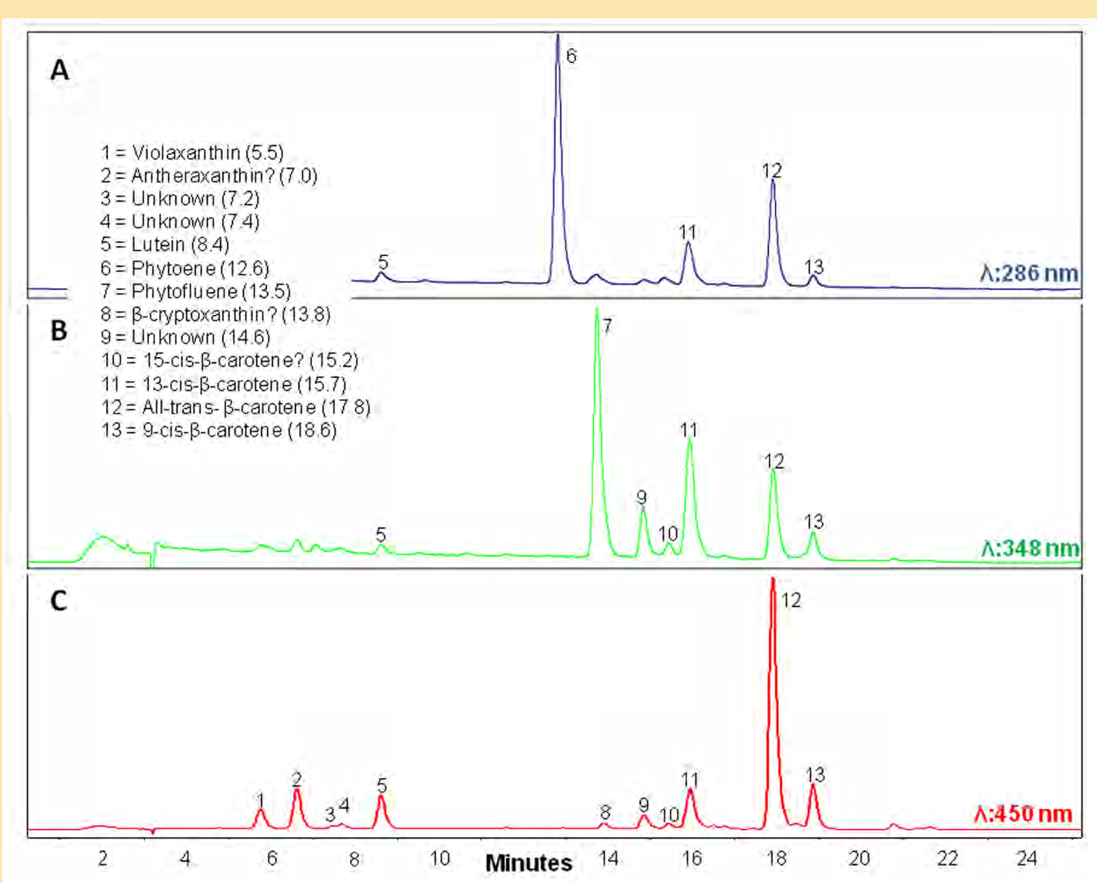
Introduction

In the last few years significant progress has been made improving the nutritional value of cassava roots, specifically for their pro-vitamin A carotenoids. In the process, the nutritional goal of 15 µg of β-carotene per gram of fresh root has been achieved. In addition, a large data set has been produced that allows a better understanding of the implications for the plant/root of increasing the levels of carotenoids and the inheritance of high-carotene in cassava roots. This information has been analyzed and summarized here for the benefit of those interested on the subject.

Materials and Methods

A large dataset (2129 data points) was developed over years of research to increase carotenoids content in cassava roots. Many different variables where measured but the data matrix was not complete because not all tissue samples were analyzed for all the variables.
Dry matter content (DMC): 2105; cyanogenic potential (HCN): 714; spectrophotometer data for total carotenoids content (TCC): 2127; HPLC data for TCC and different forms of β-carotene (TBC): 1970; Phytoene:1254 and Phytofluene: 676. An example of a typical HPLC chromatogram from cassava roots if provided below.



Results and Conclusions

a. If there is a correlation between DMC and TCC or TBC it would be positive. The relationship, however is weak. There is no problem, therefore, for producing biofortified cassava with adequate levels of DMC.

b. Correlation between cyanogenic potential (HCN) and TCC was negative (but also weak) suggesting that it is possible to obtain high-TCC with low HCN values.

c. Correlations of data from spectrophotometer and HPLC were very high (Figure 1). Quantifying through both equipments allows for a control of the quality of data, helping identifying suspicious data.

d. TCC and TBC had a high correlation, suggesting that most carotenoids in cassava roots are β-carotene (Figure 2).

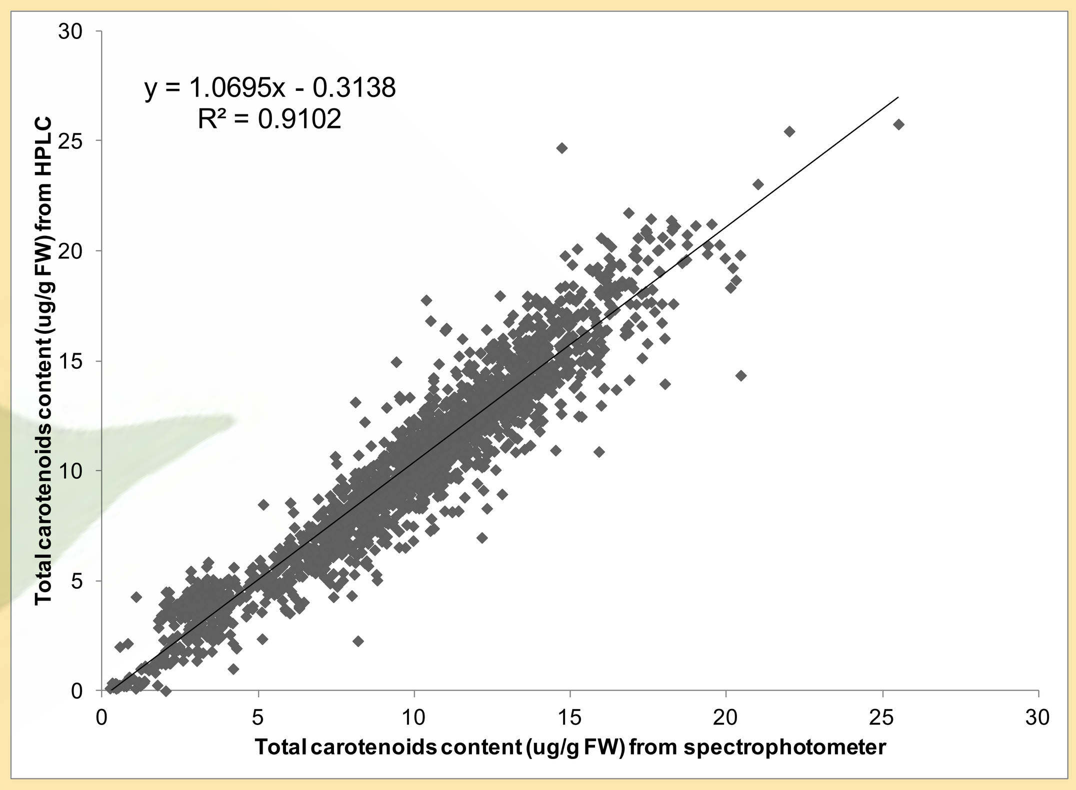


Figure 1. Relationship between total carotenoids (µg/g FW) quantified with the spectrophotometer and the same variable measured through HPLC. Graph based on 1958 data points.

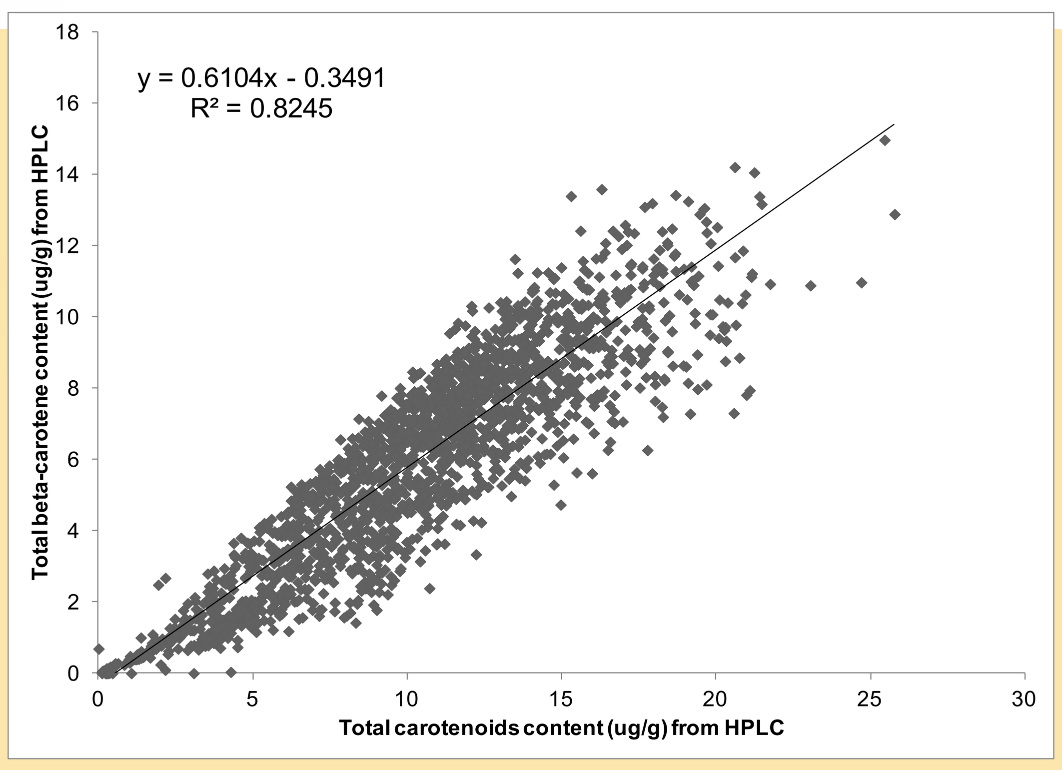


Figure 2. Illustration of the proportion of total carotenoids (µg/g FW) that is in the form of β-carotene in fresh cassava roots. Graph based on 1798 data points.

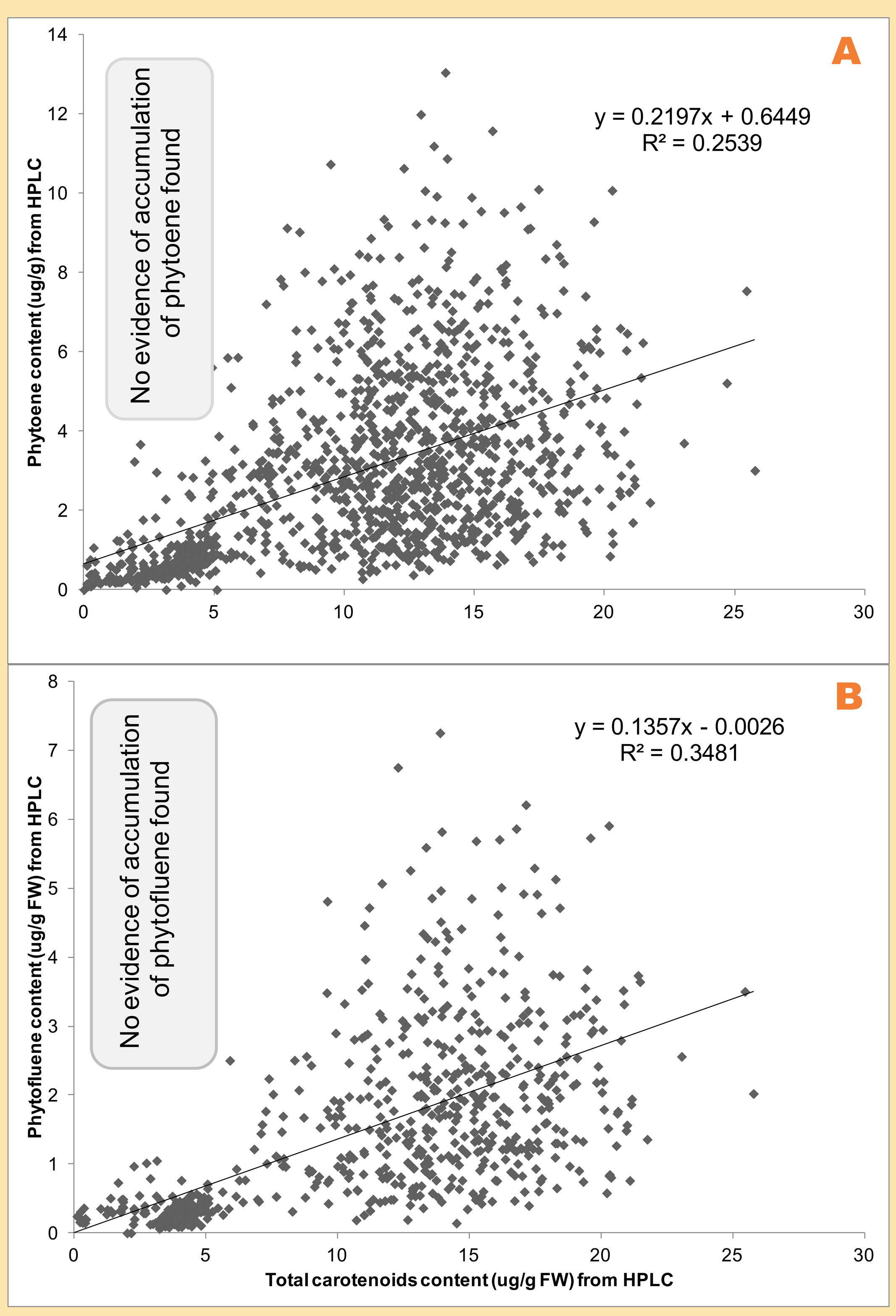


Figure 3. Relationship between total carotenoids content (µg/g FW) and **A**: phytoene (gaph based on 1254 data points); B phytofluene (graph based on 676 data points)..

e. Correlations between TCC and TBC with phytoene and phytofluene were relatively high (Figures 3A and 3B). The relationship between phytoene and phytofluene was very high (Figure 4). No case where accumulation of phytoene or phytofluene without parallel levels of carotenoids was observed. Similarly there was no accumulation of phytoene without parallel levels of phtytofluene. There is no evidence therefore, that accumulation of carotenoids in cassava roots is related to a blockage at the PSY or PDS steps in the carotenoids biosynthesis.

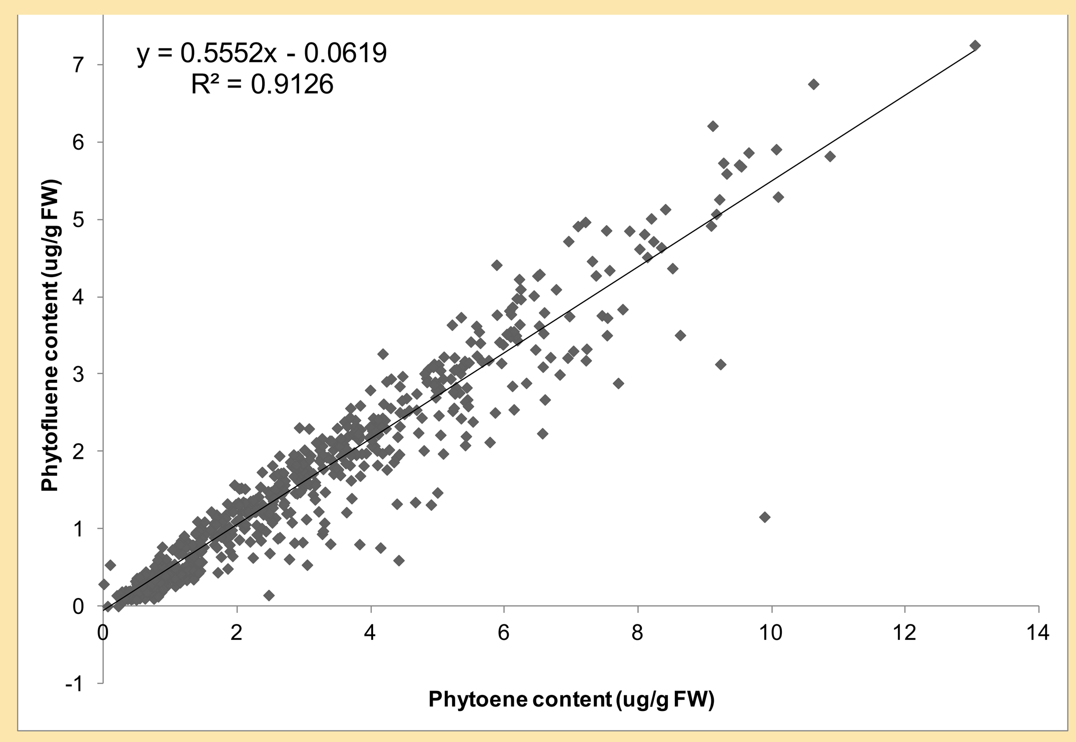


Figure 4. Relationship between the two precursors in carotenoids biosynthesis (phytoene and phytofluene) quantified (µg/g FW) with the HPLC. Graph based on 676 data points.

f. Integration of the results of many years of analyses of full-sib and self-pollinated progenies in which all genotypes were analyzed for carotenoids content allows to conclude that heritability is high (parent-offspring regression coefficient, which is equivalent to narrow sense heritability was 0.64). There is mounting evidence that there are only few genes (2-3) with a large influence on the carotenoids content in the roots. However, the continuous gains through recurrent selection (without a plateau) suggest that few modifier genes (perhaps 3-5) allow for further exploitable genetic variation. At least one major gene may have a recessive effect, perhaps diverting the pathway away from the accumulation of carotenoids (Morillo C. *et al.*, 2012).

References

Morillo-C., Y., T. Sánchez, N. Morante, A. L. Chávez, A.C. Morillo-C, A. Bolaños, and H. Ceballos. 2012. Variabilidad y estudio preliminar de herencia del contenido de carotenos en poblaciones segregantes de yuca (*Manihot esculenta* Crantz). Acta Agronómica (in press)

Acknowledgements

We acknowledge the support of HarvestPlus on funding this research

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