Metabolism of soluble sugars in 4 varieties of banana, and activity of associated enzymes

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Introduction :

Banana fruit ripens quickly (Seymour, 1993; Banana. In: Seymour GB, Taylor JE, Tucker GA, editors. Biochemistry of fruit ripening. London: Chapman and Hall, 1993. p 83-106) and sweetens as the result of starch-reserve degradation and subsequent conversion to soluble sugars: mainly sucrose, and then after glucose and fructose (Cordenunsi and Lajolo, 1995; J. Agric. Food Chem. 43:347:351). The metabolism of sucrose has been studied, but mainly on varieties of Cavendish group. To get more insight sucrose metabolism of this fruit, we took into account 4 different varieties of our collection, not linked to Cavendish group, and considered as dessert or cooking ones. We determined their amounts in sucrose, glucose and fructose, and we measured main enzyme activities of sucrose metabolism to clarify the relationship between these activities and the amounts of sugars as a function of biodiversity.

Material and methods :

The 2 dessert varieties were IDN 110 (*Musa diploid Acuminata*) and Kirun (*Musa diploid Acuminata*). The 2 cooking ones were Galéo (*Musa diploid Acuminata*) and Sowmuk (*Musa diploid Acuminata*). Fruit ripening occurred on banana plant. The length of the growth step before ripening is designated as the "**I**nterval between **F**lowering and the first **Y**ellow banana appearing in the bunch" (IFY). The IFY is defined in accumulated temperature degrees, based on a heat-unit concept (Ganry and Meyer, 1975; Fruits 30:375-392). Harvests of green fruits of the median hand were made firstly according to this heat-unit scale at 75% of IFY [stage I] and IFY [stage II]. Then after, fruits were harvested according to a color-based scale of fruits of the median hand, based on a*-value of the L*a*b* color model measurement made with a chromameter. Stages are: **Breaker** = a*-value of green (stages I or II) fruit + 2 [stage III], **green equal yellow** = -16<a*-value <-12 [stage IV], **light-yellow** = -9<a*-value<-5 [stage V], **fully dark-yellow** = -3<a*-value<0 [stage VI], **fully dark-yellow plus eventual brown patches** = 0<a*-value [stage VII]. Sugars were measured as described by Fils-Lycaon et al. (2008; Fruits 63:187-191). Sucrose-Phosphate Synthase (SPS), Sucrose Synthase (SuSy), and Invertase (Neutral IV and Acid IV)) extractions and assays were conducted with methods modified from Hubbard et al. (1990; Plant Physiol. 94:201-208), and Cordenunsi and Lajolo (1995; J. Agric. Food Chem. 43:347:351).

Results :

Sugar accumulation: Figure 1 shows the accumulation of sucrose of fruit during development and ripening. The varieties Galéo and Sowmuk differed drastically from all the 2 others since their sucrose content did not increase more than 1.3% of FW. This value was obtained at stage III, an early stage of ripening. It decreased then after to get close from zero. These two varieties can almost be considered as sucrose-free. In contrast, IDN 110 and Kirun varieties, presented a high level of sucrose (7% and 8.3%, respectively of FW). Figure 2 shows the patterns of changes in total soluble sugars (determined as sucrose + Glucose + fructose) of the varieties during fruit ripening. Total soluble sugars started to accumulate at breaker stage (stage III) to reach their maximal level at stage VI. All studied varieties followed the same pattern of changes with a final and average level of sugars around 12% of the FW. It is remarkable that Galéo and Sowmuk varieties, which did not accumulate sucrose, presented an amount of total sugars close to that of the other varieties; accumulating hexoses instead sucrose.

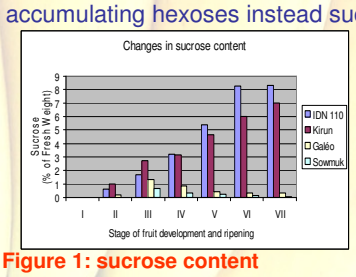

Figure 1: sucrose content

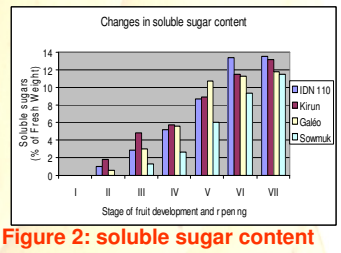

Figure 2: soluble sugar content

Sucrose synthesis: SPS activity of IDN 110 and Kirun (figure 3) increased regularly all away throughout end of green fruit development and ripening These two varieties presented a similar pattern of changes quite different from that of the 2 others. Galéo and Sowmuk presented on their side a slight decrease of activity during the last steps of development in green, between stages I and II, followed by an increase and a peak of activity at stage V, and, finally, a decrease during the end of ripening.

Sucrose hydrolysis: All varieties presented the same levels of SuSy activity working in the sucrose hydrolytic way and the same pattern of change. This pattern was characterized by a low activity around 28 µmoles of fructose / h / g of FW at stage I, sharply decreasing to 3 µmoles / h / g of FW just at the beginning of ripening (data not shown).

NIV activity was found very low, around 5 µmoles of glucose / h / g of FW without significant changes during fruit ripening, or significant differences among varieties (data not shown).

Changes in AIV are presented in figure 4. AIV activity of all varieties increased during ripening of fruit but the evidence is that than of Sowmuk and Galéo varieties increased dramatically (at stage III fand IV, respectively to reach approximately 170 µmoles of glucose / h / g of FW at the end of ripening; which represents a 6.4-higher level than that of the 2 other varieties.

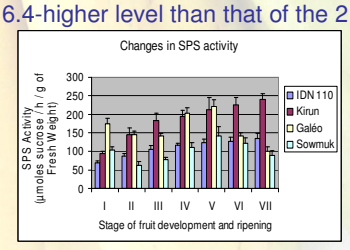

Figure 3: SPS activity

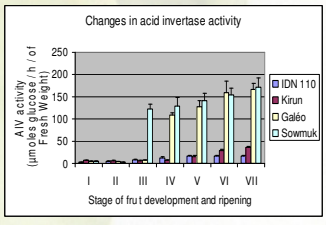

Figure 4: AIV activity

Conclusions

SPS activity increased at the beginning or during ripening of all varieties, concomitantly to total soluble sugar (sucrose + glucose + fructose) accumulation. This comforts the likely role of this enzyme in the synthesis of sucrose during ripening but we failed to find a correlation between the level of activity of the different varieties and their amount of sucrose or total soluble sugars. Interestingly, Galéo and Sowmuk varieties were found almost sucrose-free (although this is not the case for other cooking varieties (data not shown)) and presented an AIV activity 6.4-fold higher than that of the other varieties, which makes this activity as probably one of main determinants of the sugar composition of banana by correlating the ratio sucrose / glucose + fructose.

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