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MOUNTAIN BANANAS FROM THE FRENCH WEST INDIES

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ABSTRACT: Banana production is a key economic resource in the French West Indies. It is essential that growers in this region enhance their sales by proposing new products—such as mountain bananas—in response to high market competition from other exporting regions where production costs are lower. The quality of mountain bananas is officially recognised in Europe on the basis of a real taste difference. All French West Indian bananas grown at altitudes over 250 m ASL according to specifications can be sold under the mountain banana label. Mountain banana features can be assessed via objective data. At harvest stage, mountain bananas are denser, bulkier and less susceptible to wound anthracnose, caused by *Colletotrichum musae*, than lowland bananas, probably because of their higher mechanical resistance. Sensorial differences have also been documented in ripe bananas. At the same harvest stage and under identical ripening conditions, mountain bananas have a firmer texture, more intense yellowish pulp, and higher sugar and aromatic compound contents. A jury taste test analysis confirmed the sensorial differences between lowland and mountain bananas. The results of a multisite study indicated that temperature and rainfall during bunch growth are the main factors that distinguish mountain bananas.

Keywords: Banana, mountain, texture, colour, sugars, aromatic compounds

INTRODUCTION

The growing complexity of agrifood production sectors and worries prompted by certain crises have led to changes in consumer behaviour. Consumers are now looking for more authentic food products that are tastier and are traditionally prepared. Moreover, current agrifood product saturation of the European market is a major factor underlying the implementation of national and EU policies promoting the identification of agricultural and food products. Voluntary identification tools have been developed to ensure the quality and origin of products, to create added value and enable consumers to identify products with unique specific qualities. Three official European signs of quality link products and their origins: protected designation of origin (PDO), which is the European equivalent of the French Appellation d'Origine Contrôlée (AOC); protected geographical indication (PGI), and the Mountain label. For PDO, product qualities are associated with a *terroir* and traditional practices. PGI designates products originating from a region, so that quality can be attributed to this origin. The mountain label applies to products for which all production and processing phases take place in mountain areas.

Banana growers in the French West Indies have decided to benefit from the positive consumer image of these signs of quality by allocating part of their production under the mountain banana label. This labeling is a way of segmenting the market and of addressing the high market competition from other exporting regions where production costs are 6 to 28-fold lower. This label also helps to preserve an infrastructure in rural mountain areas where cropping conditions are harsher. Mountain bananas of the French West Indies are grown at an altitude of over 250 m ASL and are obliged to comply with sustainable agricultural specifications. The annual production potential of mountain bananas from the French West Indies is estimated at between 15,000 and 20,000 t.

Contrary to PDO and PGI, under the mountain label it is not necessary to prove the link between the product and the mountain area. Highlighting this link does, nevertheless, consolidate the legitimacy of the mountain label, which is further enhanced by the image consumers have of mountains. CIRAD has thus conducted a number of studies on this topic over the last decade. These studies have primarily focused on Cavendish bananas as they are the main export variety. A summary of these studies follows.

MOUNTAIN EFFECT ON BANANA CHARACTERISTICS AT HARVEST

In the French West Indies, most growers decide on harvest dates on the basis of temperature sums, i.e., the sum of daily temperatures calculated over a flowering-harvest interval from a temperature threshold of 14° C for Cavendish bananas (Ganry and Meyer, 1975). Under normal conditions, a temperature sum of 1,000 degree-days from the flowering stage (emergence inflorescence) will enable bananas to grow to a mean commercial grade of 34 mm, with a sufficiently long green life for export to Europe. Considering the differences in temperature between lowland and mountain areas, the temperature sum accumulation rate is faster in lowlands than in mountain areas. Bananas require 91 days at 50 m ASL and 114 days at 280 m ASL to be able to accumulate 1,015 degree-days from flowering. However, their green life is identical, so the fruits have the same physiological age (Chillet et al., 2006; Bugaud et al., 2006).

At the same harvest stage, bananas grown in mountain areas are denser and bulkier than lowland bananas (Table 1) (Chillet et al., 2006; Bugaud et al., 2006). According to Jullien (2000) and Chillet et al. (2006), dry matter accumulation rates and grade growth are higher in mountain plantations.

Table 1: Agronomic characteristics of lowland and mountain bananas.

	Chillet (2003)		Bugaud et al. (2006)	
	Lowland (30 m)	Mountain (250 m)	Lowland (50 m)	Mountain (280 m)
Green life (d)	*24.7*[1]	*25.2*[1]	*50*[2]	*46*[2]
Density (kg/L)	-	-	0.978	0.989
Grade (mm)	33.0	35.3	35.5	38.3

[1] : measured at 20° C, [2]: at 14° C

In italics: non significant differences at 0.05

In a study carried out over a one-year period, Chillet et al. (2002) and Chillet and de Lapeyre de Bellaire (1996) noted that rheological differences between lowland and mountain bananas were greater in the rainy season than in the dry season. In the rainy season, mountain fruits were firmer, with a harder peel, whereas only fruit firmness was higher in the dry season (Chillet et al., 2002; Bugaud et al., 2006). This higher mechanical resistance in mountain bananas means that they are less susceptible to bruising during transport and storage, especially in the rainy season. This resistance is an additional key feature of mountain bananas.

Mountain bananas are less susceptible to *Colletotrichum musae*, the fungus that causes anthracnose (Chillet et al., 2000 and 2002). These differences in susceptibility could be explained by the higher mechanical resistance of mountain bananas and/or lower ethylene production (Chillet et al., 2002), but no direct relationship has yet been documented.

MOUNTAIN EFFECT ON RIPE FRUIT CHARACTERISTICS

In ripe fruit, banana storage and ripening conditions must be controlled for determining the mountain effect since these conditions can have a marked impact on the final banana characteristics. In all trials, bananas were harvested at the same physiological age (1,000 degree-days). They were then stored at 14° C for 10 to 15 days, ripened with ethylene (1,000 ppm for 24 h) and stored at 20° C until the required ripeness was reached.

Instrumental analyses highlighted significant colour and texture differences between mountain and lowland bananas (Bugaud et al., 2006 and 2007). In mountain bananas, the peel hardness, fruit firmness and yellow pulp colour intensity (expressed by parameter b* of the Hunter system) were higher, irrespective of the season (Table 2).

Table 2: Texture and colour of lowland and mountain bananas

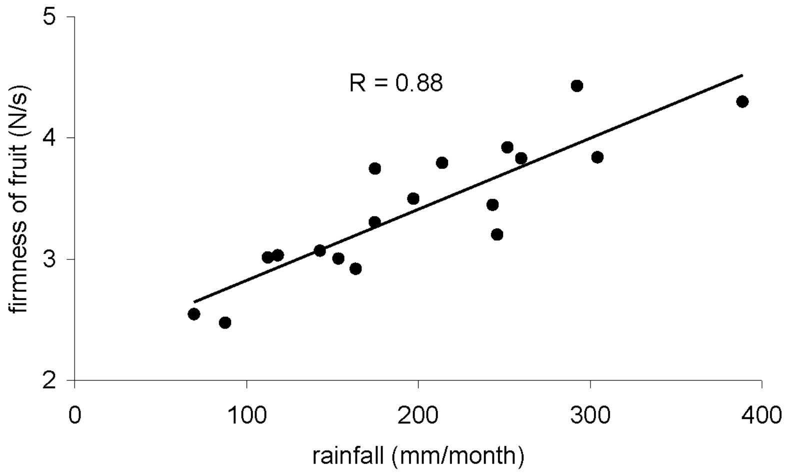
	Bugaud et al. (2006) (spotted fruit ripeness stage)		Bugaud et al. (2007) (yellow fruit ripeness stage)	
	Lowland (50 m)	Mountain (280 m)	Lowland (10-60 m)	Mountain (340 m)
Peel hardness (N)	12.1	18.3	$19.9^1 – 14.8^2$	$28.4^1 – 28.3^2$
Fruit firmness (N/s)	2.2	2.5	$3.5^1 – 2.8^2$	$4.3^1 – 3.8^2$
Yellow colour (b*)	-	-	$14.7^1 – 15.9^2$	$17.5^1 – 17.5^2$

^{1} : rainy period, ^{2} : dry period

In a study of Bugaud et al. (2007), a sensorial test involving a jury of 22 initiated tasters was carried out to classify bananas harvested during a dry period. In bananas of six different origins, including one mountain banana, 19 tasters considered that the mountain banana was firmer, thus confirming the specific sensorial features of mountain fruit.

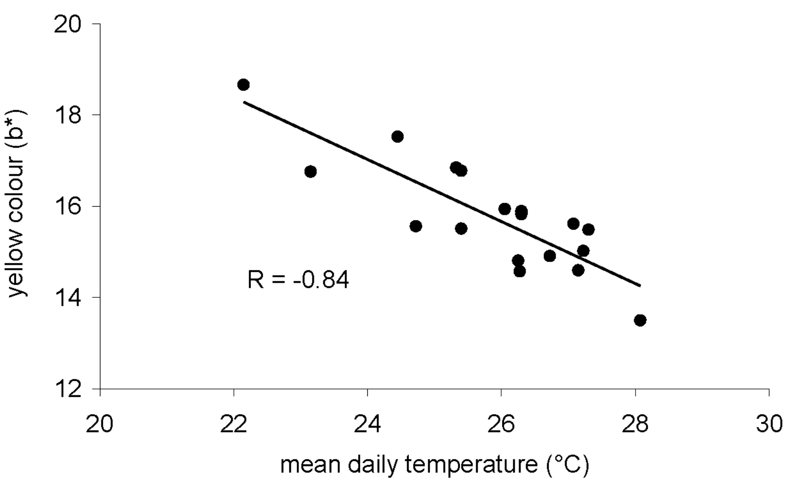
To gain greater insight into the impact of mountain growing conditions on fruit colour and texture, a multisite test was carried out over a one-year period in Martinique, at a very diverse range of sites with respect to soil and climate conditions (Bugaud et al., 2007). A positive correlation was noted between rainfall level and fruit firmness (R = 0.88) (Figure 1) and peel hardness (R = 0.80). This correlation could explain why bananas grown in highland areas, where rainfall is higher, are firmer. Ripe fruit rheological properties were not correlated with fruit water contents or with the rheological properties of green fruit. This correlation between rainfall and fruit rheological properties has been attributed to climatic variations in the activity of enzymes responsible for pectin solubilization (Chang et al., 1990).

Figure 1: Correlation between rainfall during bunch growth and ripe fruit firmness



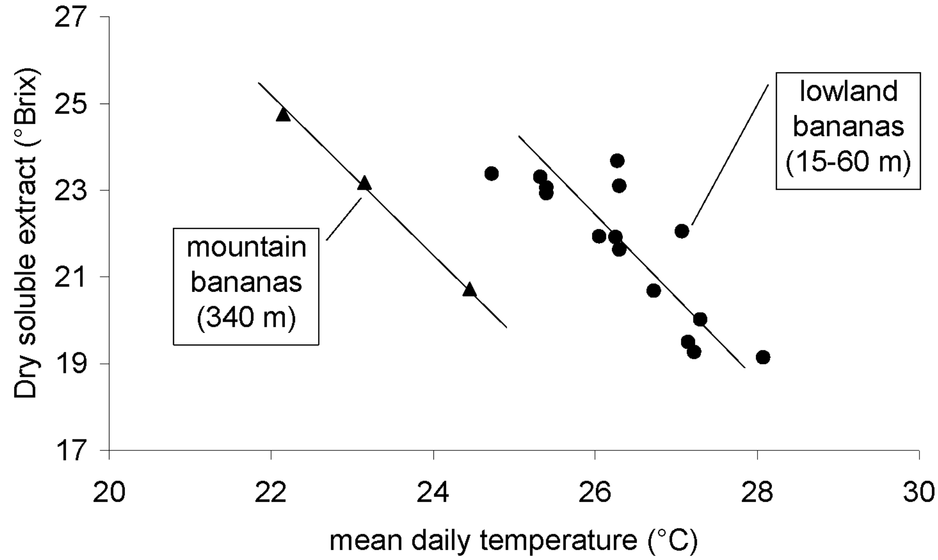
A negative correlation was also noted between the mean daily temperature and yellow fruit colour (R = 0.84) (Figure 2). This correlation could explain the yellower fruit pulp colour of mountain bananas. It is possible that the accumulation of carotenoids, which give the yellow colour to the fruit pulp, is higher in mountain bananas because of the longer time they spend on the trees.

Figure 2: Correlation between the mean daily temperature during bunch growth and ripe fruit pulp colour



The dry soluble extract, measured in °Brix, is a sugar content indicator. In ripe bananas, sugars (glucose, fructose and sucrose) represent over 50% of the dry matter content. Dry soluble extract contents were higher in mountain than in lowland bananas (Bugaud et al., 2006). However, the differences (which sometimes reached 2° Brix) were not great enough to differentiate lowland and mountain bananas in a sensorial classification test. The multisite study also revealed a decreasing correlation between the mean daily temperature during bunch growth and the dry soluble extract level in ripe bananas (Figure 3).

Figure 3: Correlation between the mean daily temperature during bunch growth and the dry soluble extract content in ripe fruit

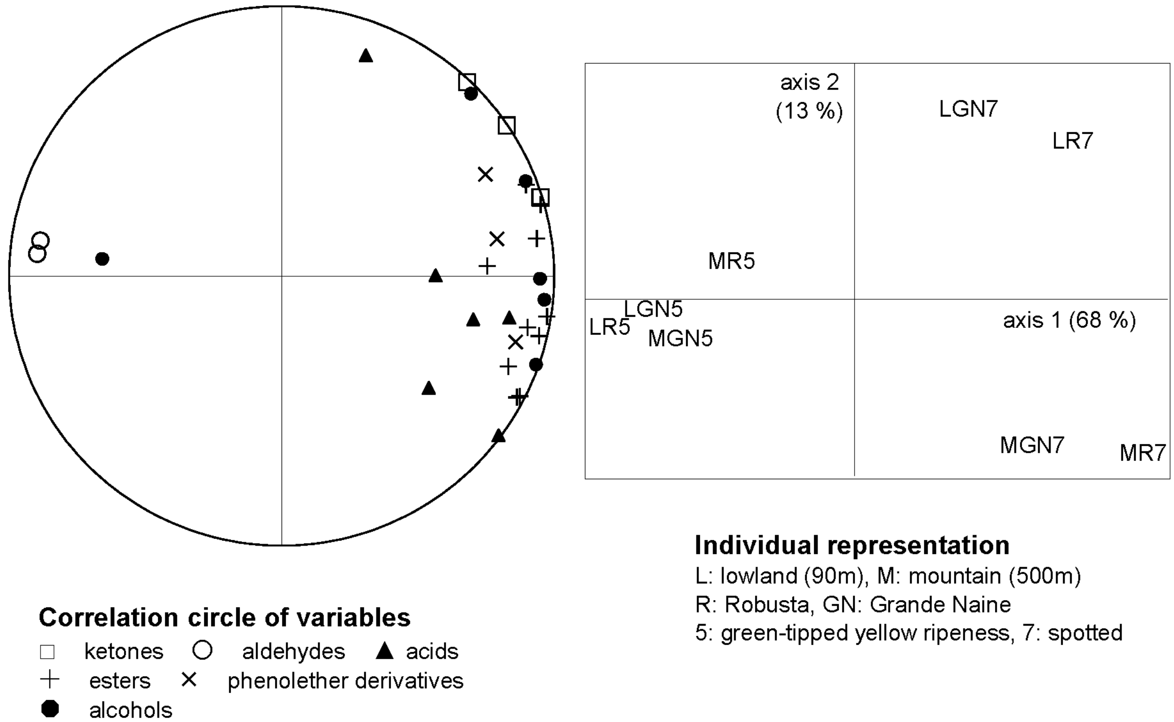


At constant solar radiation and a 1,030 degree-day temperature sum, Jullien (2000) showed that a 2° C increase in the mean daily temperature led to a 5% decrease in the green banana pulp dry weight. This decrease was also reflected first in the starch content, which is the main dry extract component at the immature fruit stage, and then in the level of soluble sugars derived from starch degradation, sugars which are an essential dry soluble extract component. This correlation could explain the higher dry soluble extract contents in mountain bananas. No significant differences were noted in the multisite study, but it is still likely that the approximately 20% lower solar radiation noted at the mountain site reduced the temperature impact on the dry matter contents of these bananas (Jullien, 2000).

From an aromatic standpoint, the volatile compound composition was studied according to elevation (90 and 500 m), ripeness stage ('green-tipped yellow' and 'spotted') and cultivar (Grande Naine and Robusta) (Brat et al., 2004). A principal component analysis revealed variations in the fruit volatile compound composition (Figure 4).

The volatile compound contents increased overall during fruit ripening. Differences between lowland and mountain bananas were noted at the most advanced ripeness stage. Ketones (fruity aroma compounds) were more abundant in lowland bananas. Mountain bananas had the highest levels of esters (also fruity aroma compounds) and carboxylic acids, except for hexanoic acid. Concentrations of isoamyl acetate, a typical aroma in bananas, were found to be 40 to 100% higher in mountain bananas. These aromatic compound differences could explain the sensorial differences noted when the same bananas were assessed in the taste tests (Brat et al., 2004).

Figure 4: Principal component analysis of the volatile compound composition in bananas



CONCLUSION

There are real differences between lowland and mountain bananas, differences which first appear at the immature fruit stage and increase with ripening. The physicochemical and sensorial differences documented are beneficial for the French West Indies banana industry with respect to promoting and marketing mountain bananas. Another feature of mountain bananas is that they are less susceptible to the fungus that causes anthracnose. Sustainable cropping practices with low fungicide use is an additional argument in favour of this label. Finally, growing mountain bananas at an altitude over 250 m ASL, in compliance with the specifications for this product, is highly warranted in the light of the study results.

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