Evidence on the Effect of the Cocoa Pulp Flavour Environment during Fermentation on the Flavour Profile of Chocolates

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Abstract

Empirical observations carried out by the first author during his many visits to cocoa producing countries suggested that a relationship might exist between cocoa pulp flavour attributes and sensory traits of cocoa liquor and chocolates. A first attempt to demonstrate such a relationship was made by evaluating the following flavour attributes: volatile aroma upon opening the pods, pulp sweetness, pulp acidity, pulp astringency, pulp flavour intensity and type, overall preference for pulp taste, and degree of bitterness of the cotyledon. Blind pulp tasting was carried out by a six-person panel of ripe fruits of nine cocoa clonal varieties, representing different genetic origins, several of which are well known for their contrasting sensory traits of their chocolates. Overall pulp preference was significantly related to the known fine flavour potential of the cocoa varieties tested, whereas specific pulp flavour attributes appeared related to specific types of fine flavour of the tested cocoa genotypes. One striking example was the EET 62 clone (Nacional x Trinitario), which displayed a "jasmine" flower odour upon opening the ripe fruit, sweet pulp with an intensive pleasant flavour that was identified as floral and fruity. These flavour attributes are apparently related to the known typical "Arriba" flavour of the EET62 clone. The typical fresh-fruit Trinitario cocoa flavour of the ICS 1 clone appeared to be related to a balanced combination of relatively high acidity and sweetness and a moderate citrus-like flavour of its pulp. On the other side, the pulp of the potentially low-flavour CCN51 clone was rated as very astringent and acid, with low flavour intensity and quality. The pulp of the Pandora 1 clone from Colombia was characterised by a sour sop (Guanabana) flavour and may therefore represent a new interesting type of fine-flavour cocoa. These results suggest that a significant part of fine-flavour attributes of cocoa products (excluding basic cocoa flavour) can be related to sensory traits identifiable in the pulp of ripe cocoa pods.

The effect of the pulp flavour environment on the taste of chocolates was further experimentally demonstrated by adding equal quantities of aromatic pulp of two tropical fruit species (*Theobroma grandiflorum* and *Anona muricata*) with Amelonado beans during the fermentation process. The chocolates obtained by this method revealed the

presence of the typical flavour attributes of *T. grandiflorum* and *A.muricata.* This shows that the added aromatic compounds are absorbed by the cocoa cotyledon during the fermentation process. An amateur public in Montpellier, France, showed high levels of preference for the chocolates that had acquired flavours of *T. grandiflorum* and *A. muricata* in comparison to that of the pure Amelonado control treatment.

The combined findings suggest that:

1) Rapid screening of germplasm and of breeding populations for pulp characteristics can be attempted to select cocoa varieties that display good potential for known as well as for new fine flavor traits,

2) Chocolate flavors can be modified substantially by adding aromatic substances to cocoa beans during the fermentation process. The further development of such an innovative way to produce cocoa liquors and chocolates with enhanced and/or modified flavour profiles is expected to have important commercial applications. It would also provide new opportunities for the use of aromatic tropical fruit pulps that are often under-utilized and under-valued.

Introduction

Objectives of cocoa breeding include high yield, resistance to diseases and pests and good quality. Quality of fine flavour cocoas is known to be affected by genetic and geographic origin, and thus breeding programmes have aimed at maintaining the cocoa flavour associated with the country of origin (Lockwood and Eskes 1996). Research on cocoa flavour has been receiving increasing attention over the last 15 years and has broadened the spectrum of recognised flavour traits (*e.g.* Clapperton *et al*. 1994; Eskes 2006; Sukha and Butler 2005). Besides variation in the intensity of basic cocoa flavour, presence of specific aromas such as “fruity” (*e.g*. as found in Trinitarios), different types of “floral” (*e.g*. as Nacional and Scavina types), and nutty and caramel flavours (*e.g*. in Criollo types) have been demonstrated (Sukha and Butler 2005). The market for fine flavour cocoa (mainly as dark chocolate with high cocoa content) is rapidly expanding and diversifying, providing new opportunities for the producers to obtain premium prices for high quality cocoa beans. Besides selecting for traditionally recognised fine flavour cocoa types, the challenge for breeders is also to look for new fine flavour types that may be of interest for the cocoa market.

Cocoa breeding is complex, as many traits need to be selected for simultaneously. Selection for special flavour attributes is a laborious and time-consuming process that requires collaboration between breeders, specialists in post-harvest technologies, sensory specialists and chocolate manufacturers. Most cocoa selection programmes do not have the capacity to carry out routine sensory evaluations of genotypes in their collections or in the breeding populations. These factors reduce the efficiency and speed of progress in the selection of fine flavour cocoa types, especially if this trait is to be combined with good yield and resistance to diseases. Therefore, the use of a quick method to identify special flavour traits of cocoa genotypes would be very useful in cocoa breeding.

Regular visitors to cocoa plantations are familiar with the broad variation that exists in the taste of cocoa pulp. The most conspicuous variations that can be observed are related to the level of acidity and sweetness. This is especially noticeable when pulp of cocoa pods of different genetic origins is tasted. For example, it is well known that Criollo and Scavina genotypes have very sweet pulp whereas the pulp of Trinitario and Forastero clones are generally more acid. Sensory traits of the pulp and of the beans (degree and type of bitterness) have been used over the last 10 years in Ecuador as criteria for pre-selection of trees that might produce the “Arriba” flavour profile associated with the Nacional cocoa variety (Gilles Roche, CIRAD, personal communication), but no published studies exist on the possible relationship between pulp traits and fine flavour cocoa.

The first objective of the current study is to assess if variation in sensory traits of the pulp in ripe cocoa pods from different genetic origins are related to the known variation of fine flavour traits of cocoa beans.

The second objective of the present study was to determine the effect of the cocoa pulp flavour environment on the final flavour of the liquors prepared from the fermented and dried cocoa through adding aromatic pulp of two fruit species and of an aromatic spice to the wet beans of a Forastero cocoa (Amelonado) during the fermentation process.

Materials and methods

Study 1.1

In September 2007, an experiment on flavour attributes of ripe pulp of different cocoa types from the cocoa genebank of the Universidad Nacional Agraria de la Selva in Tingo Maria, Peru, was carried out. The varieties chosen included genotypes that are known to vary for fine flavour attributes (Table 1). EET 62 is associated with the Arriba floral flavour and ICS1 with the typical Trinitario fruity flavour. The Ucayali (U) and Huallaga (H) clones represent sub-spontaneous and cultivated origins collected in the Huallaga and Ucayali river basins, respectively (Garcia Carrion 2000; Dapeng Zhang *et al*. 2006). The Huallaga accessions appear to be mainly true Forasteros while some are of hybrid origin.

Two ripe pods of each of nine clones were collected in the morning, numbered 1 to 9, and placed in the laboratory for sensory evaluation of the mixed pulp and beans in the afternoon. The mixing of the pulp of the two pods seems justified by previous field observations made by the some of the authors that suggested low variation in pulp flavor traits between well ripe pods from the same tree or from different trees from the same clone. The panel consisted of six persons, composed of 5 scientists working at the UNAS University and of the main author. They scored the following flavour attributes on a 0 to 5 point scale: intensity of volatile aroma (odour) when opening the pod, pulp acidity, pulp sweetness, pulp astringency, bean bitterness, presence of a special flavour in the pulp after tasting it, the type of flavour of the pulp and overall preference of the panellists for the taste of the pulp. There were deliberations among panellists after the tastings were finished, but no modifications in the individual panellists’ scoring were carried out. The panellists had some previous experience in evaluating pulp flavour differences between individual cocoa trees and between clones in the field, during which opinions had been shared between panellists on scoring of intensity of different flavour traits. No further calibration of panellists occurred before the laboratory tastings.

The panellist scores were individually recorded and maintained for statistical analyses. Classical statistical analyses using linear models (ANOVA, linear correlation) were performed to calculate the treatment effects, and Principal Component Analysis (PCA, using the XLSTAT 2007 programme version 8.01) was done to visualise the associations between traits and treatments.

Study 1.2

A small-sized study of chocolates has been made with cocoa harvested from two individual cocoa trees in Trinidad selected for expression of strong pulp flavours resembling banana and sour sop, respectively, in 2008 and 2010. The fermented and dried beans were transformed into chocolates at Mars Inc. and evaluated by those involved in this study.

Study 2

Addition of aromatic pulp of two tropical fruits

Frozen pulps extracted from ripe fruits of two tropical fruit species, *Theobroma grandiflorum* (cupuaçu) and *Anona muricata* (sour sop, graviola or guanabana), were used in mixtures with cocoa beans under micro-fermentation conditions. The aromatic pulps of these fruits are used in Brazil and elsewhere to produce aromatic ice-creams and fresh fruit juices. Five treatments of micro-fermentation were applied using a fermentation mass made up of wet cocoa beans of the Amelonado cocoa type ("Comun" variety) growing in the farm "Boa Sorte" in Uruçuca, South Bahia, Brazil. The Amelonado variety is known to produce "bulk" cocoa quality, with intense cocoa flavour but generally with little or no fruity flavour.

The fermentations were carried out in Ilheus, January 2007, in a wooden box of 50x50x50cm that was filled with healthy wet cocoa beans. The fermentation mass was turned 48, 72, 96 and 120hrs after the initiation of the fermentation process and total fermentation duration was 6 days (144hrs). The micro-fermentations were carried out by placing one kg wet cocoa beans, alone or mixed with an equal quantity of aromatic pulps of cupuaçu and of sour sop, in polystyrene netted bags in the middle of the fermentation mass permitting good exchange of fluids between the fermentation masses inside and outside the bags. The following treatments were applied, each with two replicates:

- *Treatment 1 (control).* Micro-fermentation of a sample of one kg of cocoa beans without addition of aromatic pulp. The cocoa bean sample was obtained by putting beans from the Amelonado fermentation mass into two micro-fermentation bags (replicates) 24hrs after the beginning of the fermentation process. The micro-fermentation bags were then placed in the middle of the fermentation mass.
- *Treatment 2.* Micro-fermentation of cocoa beans, obtained from the fermentation mass 24hrs after the start of the fermentation, with cupuaçu pulp. The mixture was placed in two micro-fermentation bags (replicates), each containing one kg of cocoa beans and one kg of cupuaçu pulp. The bags were placed in the middle of the fermentation mass 24 hrs after the start of the fermentation process.
- *Treatment 3.* Micro-fermentation of a mixture cocoa beans and cupuaçu pulp, as in treatment 2, but with addition of the cupuaçu pulp to cocoa beans taken from

the fermentation mass 48hrs after the start of the fermentation process and with initiation of the micro-fermentation at the same time.

- *Treatment 4.* As treatment 2, but with addition of pulp of sour sop (*Anona muricata*), instead of cupuaçu pulp.
- *Treatment 5.* As treatment 3, but with addition of pulp of sour sop (*Anona muricata*), instead of cupuaçu pulp.

The micro-fermented and sun-dried cocoa bean samples produced by these five treatments were sent to Montpellier, France, in May 2007, where nib flavour traits were assessed in May 2007 by the first and the fifth author. Cocoa liquors and chocolates (65% cocoa finished chocolate consisting of 55% nibs, 10% deodorised cocoa butter, 35% cane sugar and 0.35 soya lecithin added) were made by the Guittard Chocolate Company in September/October 2007 with beans from the five treatments. The fourth author carried out a descriptive sensory evaluation of the liquor and chocolate samples. The chocolates were sent by Guittard to Montpellier in November 2007. The chocolate samples were evaluated for flavour traits by the first and fourth author and for preference by an amateur public jury in Montpellier early 2008.

Additional fermentations

The inventors applied separate fermentations of Amelonado cocoa beans (the same as used in Example 1) alone or mixed with four natural flavourings. The four flavourings used were three juices made with fresh pulp of aromatic fruits species (*Theobroma grandiflorum* or cupuaçu, *Annona muricata* or sour sop and *Genipa americana* or genipa) and one juice made with ginger rhizomes (*Zingiber officinale*). The fermentations were carried out in polystyrene boxes, the bottoms of which were pierced to allow fermentation fluids to drain away. Small holes were also present in the lateral walls and in the lids of the boxes to allow for adequate aeration during the fermentation process. The size of the boxes was 28 l for the mixed cocoa/fruit-juice fermentations and 8 l for the mixed cocoa/ginger-juice fermentation as well as for the control treatment (fresh cocoa beans alone). The fruit pulps and ginger rhizomes were transformed into concentrated juices in a blender by using a minimum amount of water. The juices were added to the cocoa beans 48 hrs after the start of the fermentation process in the amounts of 10% (v/v) for the fruit juices and 5% (v/v) for the ginger juice. The cocoa beans were turned three times, at 24 hrs, 48 hrs and 96 hrs after the start of the fermentation. After 6 days (144 hrs) the fermentations were stopped and the cocoa beans were dried in the sun for 8 days until reaching about 8% humidity.

Sensory evaluations of the nibs of the dry beans were carried out by two experienced cocoa researchers familiar with the taste of fermented and dried cocoa beans and with the flavours of the added fruit pulp and ginger juices.

Results

Study 1.1

Tables 2 and 3 show the results obtained for the sensory evaluation of the pulp and beans of the nine varieties (clones) tested. Differences between varieties were significant for all traits at $p=0.05$. Discrimination between varieties was highest for pulp astringency ($F=13.8$) and lowest for pulp sweetness ($F=3.5$). For ease of reading, the varieties in Tables 2 and 3 have been ordered according to the mean overall preference scores for the pulp.

The panel expressed highest *overall preference* for EET 62 and lowest preference for CCN 51 and H 56 (Table 2). The *odour* on opening the pods and the *flavour intensity* in the pulp were also perceived strongest for EET 62. The flavour intensity was intermediate for ICS 1, PAN 1, U 43 and U 45 and lowest for U 53, H 60, H 56 and CCN 51. The *pulp acidity* was highest for ICS 1, H 60, H 56 and CCN 51, and lowest for the three U clones and for EET 62 (Table 3). *Pulp sweetness* was high for six clones (EET 62, the three Ucayali clones, PAN 1, and ICS 1), intermediate for the two Huallaga clones and low for CCN 51. *Pulp astringency* was high for CCN 51, intermediate for the two Huallaga clones, low for PAN 1 and ICS 1, and very low for EET 62 and the three Ucayali clones. The *bitterness of the beans* was high for CCN 51 and average for the other varieties.

The predominant *type of flavour* identified in the pulp was “fruity” (including mainly fresh fruit flavour). The pulp of EET 62 was also considered to be “floral”, whereas the PAN 1 variety displayed a very characteristic flavour identified as that of soursop (guanabana in Spanish and graviola in Portuguese). The intense flavour of ICS 1 was considered to be a fresh fruit flavour. The pulp of the CCN 51 variety did not contain a specific flavour according to three of the panellists whereas two panellists identified a low intensity of fruity flavour.

Linear *correlation coefficients* are presented in Table 4. The odour, flavour intensity and sweetness of the pulp were all positively correlated with overall preference, and pulp flavour intensity was positively correlated with odour and pulp sweetness. Pulp acidity, astringency and bean bitterness were positively correlated with each other and negatively correlated with pulp sweetness. Pulp acidity, pulp astringency and bean bitterness were not significantly correlated with pulp preference, odour and pulp flavour.

The *associations between the genotypes and sensory attributes*, as analysed in the PCA, are depicted in Figure 1 and described in Table 5. The most contrasting varieties are EET 62 (sweet pulp with strong flavour and odour), Ucayali clones (sweet pulp with low acidity and low astringency), CCN 51 (high pulp acidity and astringency, and very bitter beans) and the Huallaga clones (acid and quite astringent pulp).

Study 1.2

The results obtained on the flavour expressions in the cocoa liquors and chocolates made with the beans from the two cocoa trees identified in Trinidad in 2008 and in 2010 for expressing high notes of specific banana and sour sop flavours in their pulps, respectively, are presented in the Annex 1.

The typical fruity flavour traits of the chocolate made with the cocoa tree that expressed a strong banana flavour in the pulp were described as:

- *“more of the banana skins / strings astringency” (Ed Seguine)*
- *“the long lasting and quite strong aftertaste remembering that of a "banana jam" (Bertus Eskes)*
- *“sweet, caramelised "cooked" fruit taste that comes across in the chocolate (Darin Sukha)*

- *“the most fruity sample I ever tasted with strong raisin and yes, the banana flavor was detectable from the mid session as a very ripe fruit banana (aligned to the “Sucrier” and “Mataburro” types of banana we have in Trinidad' (Kamaldeo Maharaj).*

The chocolates made with the cocoa tree that expressed a strong sour sop flavour in the pulp were perceived as:

- *“The explosion of exquisite mixed fruitiness from this sample had no preceding comparison. Unbelievable! However, sour sop was very difficult to discern in the fruity mix of this chocolate.” (Kamaldeo Maharaj)*

Study 2

The nibs obtained from the mixed cocoa/fruit-juice fermentations possessed fruity flavours resembling the flavours of the respective fruits used. The nibs from the mixed cocoa/ginger-juice fermentation showed a very strong characteristic ginger flavour. No fruity or ginger flavours were identified in the control treatment. The nibs of the dry beans of the mixed cocoa/fruit-juice fermentations were somewhat bitterer and more astringent than the nibs of the mixed cocoa/ginger-juice and control fermentations.

The above results suggest that:

- The flavour of the cocoa pulp environment has an effect on the flavour of the fermented and dried cocoa beans, and of chocolates made with such beans, and
- That it is possible to modify flavours of cocoa nibs, of cocoa liquors and of chocolates through the addition of aromatic substances to the cocoa beans during the fermentation process.

Discussion

Study 1

The analyses show strong effects of genotype on the sensory traits of ripe pulp. The most preferred pulps (EET 62, PAN 1, Ucayali clones and ICS 1) were sweet and rich in flavour. The EET 62 and ICS 1 clones are well-known for their floral and fresh-fruit, fine flavour cocoa traits, respectively, which might be related to the “fruity-floral/sweet” and “fruity/acid/sweet” flavours in the pulp, respectively (Table 3, Figure 4). The sweet and fruity pulp of the Ucayali clones resembles the taste of the well-known pulp of SCA 6, and might be related to the special cocoa flavour associated with the SCA 6 clone. The two Huallaga clones had acid pulp and did not show any special pulp flavour. These pulps are similar to that of many known Forastero types (such as IMC 67), which may have a good potential for strong cocoa flavour, but do often not have special flavour attributes. Interestingly, the H 60 had an odour on opening the pod that was not observed for H 56. This might be due to the likely hybrid origin of this clone (Table 1), including possibly SCA 6 as one of the parents (Dapeng Zhang, personal information). The least preferred pulp (CCN 51) was acid, very astringent and presented little or no special pulp flavour. This might be related to the reported presence of acidity and astringency in cocoa liquors made of CCN 51 beans that have not undergone special fermentation treatments to remove these unfavourable traits.

Interestingly, while the sweet and acid traits were generally opposed traits, the pulp of ICS 1 appeared to have considerable levels of both acidity and sweetness. This is why this clone is located in the middle of Figure 1. The combination of sweet and acid pulp could well be related to the origin of ICS 1 (a Trinitario clone), descending from hybridisation between Criollo (sweet pulp) and Forastero (acid pulp). The not well known PAN 1 also has a similar acid/sweet pulp, but it had also a very typical soursop flavour. Therefore, the cocoa products made with beans of this clone may also display a soursop related flavour that could be a new flavour to the current spectrum of fine flavour cocoa traits.

The relationship between cocoa pulp flavour traits and traits of cocoa products (liquor or dark chocolate) could possibly be due to the presence of aromatic substances or aroma precursors in the pulp that may migrate into the cocoa beans during the fermentation process. As indicated by Rohsius *et al*. (2006), the mycropyle of the cocoa bean becomes permeable during the fermentation process allowing for the entry of acetic acid and other soluble compounds into the cotyledon. It may, however, also be that some of the aromatic substances that are present in the beans are also present in the pulp. Our findings do not suggest that the strength of the basic cocoa flavour in cocoa products is related to any characteristic of the pulp.

More research is certainly required to further verify and possibly explain the relationship between pulp flavour traits and flavour of cocoa products. These studies could involve comparisons between pulp flavours and flavours of cocoa liquor of diverse genotypes, and fermentation of de-pulped beans with low fine flavour potential in fermentation boxes that contain a pulp of rich flavour, and vice-versa.

Although the potential for fine flavour cocoa is much determined by the cocoa genotype, it is recognised that the environment, post-harvest handling and chocolate preparation techniques may equally affect the flavour of cocoa products. Our results suggest, however, that rapid screening of germplasm and of breeding populations for pulp characteristics can be attempted to select cocoa varieties that display good potential for known as well as for new fine flavour traits.

Study 2

Effect of the cocoa pulp flavour environment

The main effect of the aromatic pulp addition during the cocoa fermentation process was related to fruity flavour traits. The effect of the cupuaçu pulp appeared to be stronger that that of the sour sop pulp. This is in agreement with the intensity of the typical flavours of these fruit species, with the sour sop flavours being milder than the cupuaçu flavours.

The addition of aromatic pulps also appeared to reduce cocoa flavour intensity and to increase the astringency of the chocolates. These secondary effects might be caused by transfer of astringency from the aromatic pulps to the cocoa beans, or due to a modification in the fermentation conditions caused by the addition of the aromatic pulps. High levels of astringency have been associated with low intensity of cocoa flavour in other studies on cocoa quality (*e.g*. Clapperton, 1992).

The slight fruity flavour identified in treatment 1 (control) appeared to be complex in nature. It might in fact be a mixture of the flavours from cupuaçu and sour sop, which resulted from some transfer of fruity flavours between the micro-fermentation bags.

Effect of the timing of the micro-fermentations

The slightly stronger fruity flavour intensity found in the nibs as well as in the chocolates for micro-fermentations initiated 48hrs in stead of 24hrs after the beginning of the fermentation process (Table 1) might well be related to the germination process of the cocoa beans (Rohsius *et al.* 2006). As suggested by these authors, the speed of uptake of soluble compounds by the cotyledon during fermentation is governed by the opening of the testa, as caused by the germination of the cocoa beans occurring during the first two days of the fermentation process.

Studies 1+2

Prospects for selection of cocoa types with special quality traits

The results suggest that different pulp flavours have substantial effects on the flavour of cocoa nibs and of chocolates. This is evidence of the possibility to rapidly select cocoa varieties for specific flavour traits based on tasting of cocoa pulps, at least with respect to the highly variable fruity flavours that can be found among cocoa genotypes (Eskes *et al.* 2007). So far, cocoa pulps with the following specific fruity flavours have been identified by the authors of this paper in different countries: grapes, “Muscat” variety of grapes, mango, peach, mandarin, sour sop and banana. Study 1.2 has shown the significant effects of such pulp flavour traits on the flavours of the chocolates made with such beans (Annex 1). Further identification of such typical fruity or floral cocoa pulps would permit to substantially enhance the capacity to identify possible new exotic flavours and to speed up selection for known flavours in cocoa.

Prospects for modifying cocoa flavours by adding aromatic substances to cocoa during fermentation

As far as known by the authors, our results constitute the first demonstration of modifications of flavours in cocoa nibs and chocolates through the addition of aromatic fruit pulps to the cocoa beans cocoa during the fermentation process. This finding opens up a vast array of new opportunities to develop cocoa liquors, chocolates or other cocoa based product with special flavours through the addition of aromatic substances to the cocoa beans during the fermentation process.

The effect of the addition of the cupuaçu and sour sop pulps on the flavours of the chocolates was perceived as positive by a public panel of chocolate amateurs in Montpellier, France. This would mean that the addition of fruit pulps, as well as possibly of other aromatic substances, may have a positive effect on the quality perceived by chocolate amateurs. This suggests that our findings may well have implications of commercial interest.

Next steps

The authors realize that the results described in the current paper would require further confirmation studies, including more explanatory studies, on how the pulp flavour environment can affect the flavor of fermented and dried cocoa beans and of chocolates made with such beans. Attempts should be made to characterize specific cocoa pulp flavor traits in a large-scale evaluation of pulp flavour traits that can be found in cocoa germplasm from different countries, mainly from the Americas where cocoa occurs as a native species. Cocoa accessions that display distinctive pulp flavour traits should then be used to produce chocolates, which could be assessed for consumer preference.

The studies on additions of aromatic substances during fermentation should be enlarged to other genotypes, such as Trinitarios and to CCN51, a productive but low potential flavour clone. Specific studies would be required on how to overcome some negative side effects from the aromatic substance additions, such as increased astringency and bitterness, observed in some cases. Once fine-tuning can be obtained of this method, the commercial value of such additions needs further studies including consumer acceptance of final products made with beans produced in such a manner.

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Annex 1. Assessment of flavours expressed in cocoa liquors and chocolates made with beans from two cocoa trees expressing strong banana and sour sop flavours in the pulps of these trees

Banana flavoured cocoa pulp

Kamaldeo Maharaj, 03/07/2008, after tasting the fermented and dried beans

I cannot contain the excitement of just tasting 3 samples of dry beans of TSH 1352, 1188 and the now famous "banana" type. I had my wife join as an independent control. You will not believe that she hit the bull's eye with the banana type. It was distinct from the others aromatic fragrance. Very pleasant taste of a red cooking banana we use in Trinidad called "Mataburro", this was the same taste I had recognised in the pulp.

Ed Seguine, 29/07/2008, after evaluation of liquors and chocolates made at Mars Inc.

This is a most interesting sample! The chocolate seems to me to come across with a bit more of the banana skins / strings astringency than I would like but that possibly could be altered by playing with the roasting and conching conditions. I am not sure that the banana note, which seems to be more of a background flavour, would be forward enough to display in a blend of beans whereas the astringency would certainly come through.

Bertus Eskes, Bioversity/CIRAD, 31/07/2008, upon reception of cocoa liquors and chocolates from Mars Inc.

In the liquor, the early pungency is dominating. Then slowly the banana flavour comes through and stays for a long time (but relatively weak). Cocoa flavour is nearly absent. It does not seem evident to select this liquor as outstanding from a large amount of liquors, as compared to the chocolates. How can we explain that? Is it the magic of Ed's chocolate witchcraft?

The most significant perception of the chocolate for me is the long lasting and quite strong aftertaste remembering that of a "banana jam" (cooked ripe banana with unrefined sugar added that becomes brown/black coloured, called "bananada" in Brazil and which is eaten there mainly as a dessert or as an energy snack). The second strongest perception is the caramel taste mixed with sweetness. The third strongest perception is the upfront pungency (lactic acid?) or astringency, which gives quite quickly away for the caramel/banana flavour. Cocoa flavour is weak. Due to the continuing aftertaste of cooked banana, I like this chocolate (although a bit too sweet to my taste and I am not a special banana lover!).

Darin Sukha, CRU, Trinidad, 31/07/2008, after receiving the cocoa liquors and chocolates from Mars Inc.

I just tasted the chocolate again and must agree with the sweet, caramelised "cooked" fruit taste that comes across in the chocolate. There is no doubt about that. I would not immediately describe it as "banana" directly as I associate this term with the unique fresh fruit aroma typical of naturally ripened banana. I wonder how we would all do if we tasted this chocolate blindly, without having the word banana in our minds?

Kamaldeo Maharaj, MALMR, Trinidad, 03/07/2008, after tasting the chocolates received from Mars Inc.

Today we got the chocolate samples of the banana pulp tree from Biche (RKB3).

My thoughts: it was the most fruity sample I ever tasted with strong raisin and yes, the banana flavor was detectable from the mid session as a very ripe fruit banana (aligned to the "Sucrier" and "Mataburro" types of banana we have in Trinidad' and also evident in the pulp). However, I felt the banana parts had some floral ester type notes. The intensity of this sample developed quickly, after an initial tart sensation and lingered on. There was one flavor which I cannot place from the sample (to be further explored). I totally agree that the cocoa flavor is very low, is their some reason for this?

Two weeks ago I visited the tree, it had one very overripe pod, and the banana taste was not as strong in the earlier pods we had tasted. Maybe pulp flavor decreases with over-ripening. However, the cotyledon was very pale colored and with almost no bitterness. Overall this chocolate was really unique.

Sour sop flavoured cocoa pulp

Kamaldeo Maharaj, MALMR, Trinidad, 22/03/2012, recalling his impressions after receiving chocolates

What I can add to the above is a recent experience from the World Bank project. We identified a tree in Lopinot, Northern Range in Trinidad, with sour sop flavoured pulp, really distinct. We however discovered only last week that some remnants of the chocolates from this tree (done by Ed) in our lab fridge.

The explosion of exquisite mixed fruitiness from this sample had no preceding comparison. Unbelievable! However, sour sop was very difficult to discern in the fruity mix of this chocolate. Interestingly, the molecular work of the farmers' types pointed to Criollo and LAF's ancestry (possibly Venezuelan "Calabacillo") existing in the Northern Range in Trinidad and also in Tobago.

Table 1: Cocoa varieties from the UNAS cocoa genebank that were tested for sensory traits of pulp and beans

Variety	Country of origin	Type of clone	Genetic origin
EET 62	Ecuador	Commercial clone	Nacional x Trinitario
CCN 51	Ecuador	Commercial clone	Three-way cross
Pandora 1 (PAN1)	Colombia	Luker farm	Unknown
ICS 1	Trinidad	Commercial clone	Trinitario
U 43, U 45, U 53	Peru (Ucayali river basin)	Sub-spontaneous cocoa types	Forastero
H 56	Peru (Huallaga river basin)	Farm selection	Forastero (1)
H 60	Peru (Huallaga river basin)	Farm selection	Forastero x Scavina (1)

(1) According to ancestry inference analysis of molecular data (Dapeng Zhang, personal communication)

Table 2: Overall preference and aroma perception of cocoa pulp from nine cocoa varieties

Variety	Overall preference	Odour on opening the pod	Pulp flavour intensity	Predominant pulp flavours [2]
EET 62	4.3 *a* [1]	3.9 *a*	4.0 *a*	Fruity,floral
PAN 1	3.2 *b*	1.7 *d*	2.5 *bc*	Soursop
U 53	2.8 *bc*	1.9 *cd*	1.8 *cd*	Fruity
U 43	2.8 *bc*	2.6 *bc*	2.3 *bc*	Fruity
ICS 1	2.7 *bcd*	2.3 *bcd*	3.0 *b*	Fruity
H 60	2.3 *bcd*	3.0 *b*	1.8 *cd*	Fruity
U 45	2.3 *bcd*	2.2 *bcd*	2.2 *bcd*	Fruity
CCN 51	2.0 *cd*	1.5 *d*	1.3 *d*	No aroma, fruity
H 56	1.8 *d*	1.5 *d*	1.7 *cd*	Fruity
Mean	**2.7**	**2.3**	**2.3**	
F-value panelists	**2.07** ***ns***	**2.6 ***	**4.7 ***	

[1] Different letters identify significant differences between means according to Duncan's test at 5% probability

[2] Identified by at least two out of the six panellists

Table 3: Perception of acidity, sweetness and astringency of cocoa pulp and bitterness of the beans (cotyledons) from nine cocoa varieties

Variety	Pulp acidity	Pulp sweet-ness	Pulp astrin-gency	Bean bitter-ness
EET 62	1.5 *cd* [(1)]	3.2 *a*	0.7 *d*	2.2 *bc*
PAN 1	2.3 *bc*	2.8 *ab*	1.3 *cd*	2.8 *b*
U 53	1.2 *d*	3.0 *ab*	0.7 *d*	1.8 *c*
U 43	1.2 *d*	3.0 *ab*	1.2 *d*	2.5 *bc*
ICS 1	2.8 *ab*	2.8 *ab*	1.3 *cd*	2.5 *bc*
H 60	2.8 *ab*	2.0 *bcd*	2.2 *b*	2.3 *bc*
U 45	1.0 *d*	2.7 *abc*	0.7 *d*	2.0 *bc*
CCN 51	3.5 *a*	1.5 *d*	3.3 *a*	4.2 *a*
H 56	3.0 *ab*	1.7 *cd*	2.0 *b*	2.5 *bc*
Mean	**2.2**	**2.5**	**1.5**	**2.5**
F-value panelists	**2.4 *ns***	**1.7 *ns***	**5.8 ****	**8.5 ****

[(1)] Different letters identify significant differences between means according to Duncan's test at 5% probability

Table 4: Coefficients of linear correlation between pulp and bean flavour attributes of nine cocoa varieties

	Odour at opening the pod	**Pulp flavour intensity**	**Pulp acidity**	**Pulp sweet-ness**	**Pulp astrin-gency**	**Bean bitter-ness**
Overall preference	0.70 * [(1)]	0.88 **	- 0.48	0.78 *	- 0.61	- 0.32
Odour at opening the pod		0.73 *	- 0.38	0.50	- 0.40	- 0.42
Pulp flavour intensity			- 0.36	0.72 *	- 0.62	- 0.36
Pulp acidity				- 0.81 **	0.87 **	0.71 *
Pulp sweetness					- 0.91 **	- 0.63
Pulp astringency						0.84 **

*[(1)] The level of significance is indicated by * (α=0.05) and by ** (α=0.01)*

Table 5: Description of typical pulp and bean flavour attributes of nine cocoa varieties

Variety	**Description**
EET 62	Intensive odour and fruity and floral sweet pulp
CCN 51	Astringent and acid low flavour pulp, very bitter beans
Pandora 1 (PAN1)	Sweet pulp with characteristic soursop flavour
ICS 1	Acid and sweet, intensive fresh fruit flavour
U 43, U 45, U 53	Sweet pulp with medium flavour intensity
H 56, H 60	Acid, medium astringent, low sweetness and low fruity flavour

Table 1. Results of sensory evaluation carried out at CIRAD, Montpellier, of cocoa beans and chocolates obtained from Amelonado cocoa beans fermented alone (Treatment 1), or in mixture with pulp of cupuaçu (Treatments 1 and 2) and of sour sop (Treatments 4 and 5) added to the cocoa beans 24 or 48hrs after initiation of the fermentation process.

Treatment	Flavour type	Nibs (1-5 scale)	Chocolates (1-5 scale)
1	Fruity (complex)	0	1
	Cocoa flavour	-	3
	Astringency	-	1
2	Fruity (cupuaçu)	2	4
	Cocoa flavour	-	2
	Astringency	-	2
3	Fruity (cupuaçu)	3	5
	Cocoa flavour	-	2
	Astringency	-	3
4	Fruity (sour sop)	1	2
	Cocoa flavour	-	2
	Astringency	-	4
5	Fruity (sour sop)	2	3
	Cocoa flavour	-	2
	Astringency	-	3

Figure 1: Principal Component Analysis plot for five sensory traits of the pulp and for bean bitterness of nine cocoa varieties. The percentages between brackets indicate the percentage of variation explained by axis 1 (F1) and axis 2 (F2).