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Quality Matters

The message of this issue is that quality matters. The consumer, who drives the cocoa economy, demands it. We illustrate how quality is important throughout the cocoa supply chain: from quality planting stock to environmentally sound, locally appropriate production methods and good post-harvest practices. We look at how cocoa agroforestry systems protect biodiversity and the environment, and enhance the quality of farmers' lives. We also see how consumer perceptions of quality may affect farmer decision making.

Quality, in all its forms, is an essential building block for a sustainable cocoa economy to secure the future of the industry. Each link in the cocoa supply chain has a part to play in this key area.

A mature pod from TSH 919 at the La Reunion Estate, Centeno, Trinidad (see p. 4) (D.R. Butler)

Cocoa Quality, a Chocolate Manufacturer's Perspective

Quality standards in the manufacture of foodstuffs are the responsibility of everyone in the chain, from the farmer producing raw materials through to the retailer displaying and selling food items. Stakeholders in the cocoa supply chain (growers, cooperatives, exporters, shippers, warehouse keepers, processors, manufacturers, retailers) share an interdependence: each relies on the previous link in the chain to add value and maintain quality standards. From the chocolate manufacturer's perspective, the goal is to deliver the quality the consumer expects over time without deviation. In the words of one major manufacturer "the consumer is our boss, quality is our work, and value for money is our goal." Retailers and consumers demand quality and they expect their favourite brand to look, feel, smell and taste exactly the same as it did the last time they purchased it. Quality defects can lead to an unsatisfied consumer, a loss of confidence in a brand and no repeat purchases, with a negative impact on overall cocoa consumption.

Annual world cocoa production is 3 million tonnes of beans, of which approximately 1.1 million tonnes are needed to make cocoa liquor, the flavour (and colour) component of chocolate. The remaining 1.9 million tonnes are mainly made into cocoa butter and cocoa powder. Cocoa butter is also used in chocolate manufacture, but cocoa powder is used in a variety of foods (drinks, ice cream, baked goods, etc.) as a flavouring and colouring.

The engine which drives the world cocoa economy is the purchase and enjoyment by millions of consumers of products made entirely or in part from chocolate. The markets for high cocoa containing dark chocolate and for white chocolate are significant and growing, but it is currently milk chocolate that enjoys the strongest growth worldwide. Forecasts predict that this will be the case in developing markets such as eastern Europe, India and China.

The main ingredients of milk chocolate are sugar, milk solids, cocoa butter and cocoa liquor, and it is the cocoa ingredients which contribute texture, aroma, colour, mouthfeel and flavour to the product. The quality of the cocoa ingredients is crucial in driving cocoa consumption worldwide, and is key to chocolate products competing successfully in a marketplace offering consumers many choices.

It is, however, sometimes hard to reconcile the concept of cocoa as a high quality food ingredient when one sees evidence of poor quality practices such as the degradation of cocoa beans with debris, poor drying, inappropriate storage, etc. The presence of high levels of debris can in part be attributed to the rapid growth of the cocoa sector in some producing countries, which has made it difficult to establish quality systems. This underlines the importance of getting quality systems right from the outset as new countries or regions begin to produce cocoa, e.g. Vietnam. The 'buy everything regardless of quality' culture in some cocoa supply chains does not reinforce a quality message in the pipeline from producer to consumer. What does support the desire for good quality cocoa is the way it can impact on differential market prices. For example, there is a premium for Ghana cocoa (due to its physical quality, fat content and, indirectly, flavour), whereas discounts are applied to cocoa from some other producing countries (due to debris, bean size, fat content, etc.).

Compliance with Basic Food Safety

The first quality consideration within the cocoa pipeline is that cocoa beans and cocoa raw materials comply with basic food safety standards, and that production methods follow good agricultural practice (GAP). As with any other agricultural raw material, this means environmentally responsible production, using only approved inputs, giving produce reasonably free from pesticides or any other agrochemical residues.

Cocoa butter and cocoa liquor come from cocoa nibs, fragments of the cotyledons of the cocoa bean kernel. The bean kernels are encased in a shell or husk, and these develop inside a thick-walled pod until harvested by the farmer. This means that provided the cocoa pod remains intact, the edible part of the bean is exceptionally well

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Constructing a good fermentation heap in Côte d'Ivoire. Wet cocoa beans are piled on banana leaves, covered and left for about 6 days, turning the heap once (Martin Gilmour)

protected by a form of natural packaging from environmental contamination. Cocoa beans are roasted as part of the cocoa liquor manufacturing process to develop cocoa flavour but this also has a desirable side effect of killing microorganisms.

Various food scares, mainly in the European Union (EU) have created an atmosphere of suspicion around food supply and manufacture. Also, the ability of analytical chemists to identify minute traces of residues or environmental contaminants in foodstuffs is increasing yearly. These factors, combined with an earnest desire to provide consumers with nutritional, safe foods, mean that there is likely to be a stream of health and safety issues in cocoa to which the supply chain must respond. The chocolate industry is often the bearer of bad news, having to communicate the need for changes in farmer practices or supply chain logistics. Nevertheless, a positive outcome is that changes for quality reasons can catalyse better farmer organization, encourage better training, and lead to a more transparent pipeline.

An example of a recent health and safety issue in cocoa has been the potential for mineral oil residue contamination in cocoa beans. As the result of a chocolate industry initiative, the batching oil used in the manufacture of jute bags has been changed to a vegetable oil in most cocoa-exporting countries. Monitoring and remedial action will continue to eliminate this health and safety risk for cocoa imported into the consuming countries, ensuring the use of only food grade bags.

While other cocoa bean quality criteria may be somewhat dependent on the ultimate use to which a particular cocoa type is put, there is no question about the need to produce and market beans which are in complete compliance with basic food safety requirements.

Genetics and Post-Harvest Practices

Like other food crops, the cocoa variety to some extent determines the quality of the beans. Considerable effort is currently devoted to developing varieties which are resistant to pests and diseases and it is important to realise that quality attributes such as flavour and fat content should not be lost in the drive for increased productivity.

Post-harvest practices can alter cocoa bean quality dramatically, particularly the development of flavour precursors. Fermentation is usually essential to develop the precursors and optimal flavour, but slow sun drying also makes a significant contribution. The fermentation procedure to produce beans having classical 'West African' type flavour involves fermenting beans in a heap under banana leaves for 6 days, turning once, followed by drying in the sun. There are many variations of this procedure, but if the beans are being marketed for cocoa liquor, some kind of fermentation is usually necessary. Other post-harvest practices such as removing debris and broken beans, drying beans on raised platforms, careful storage, etc., all contribute to good quality cocoa beans leaving the farm.

Physical Quality Requirements

Flavour

All cocoa beans, whatever their ultimate use, should be produced using GAP in accordance with current food safety legislation as described above. Beans which are designated for liquor also need to meet quality criteria for flavour. At the absolute minimum, this means the absence of off-flavours, e.g. smokey, hammy, chemical. Usually a manufacturer will have a flavour profile for cocoa beans, which experience has shown meets the consumer expectation for a particular product when processed into chocolate. Examples of well-known cocoa flavours are Arriba (produced from Ecuador Nacional cocoa fermented for a short time) and the West African strong, recognizable cocoa flavour (produced from Amelonado-related cocoa which is heap fermented for several days).

Cocoa beans destined for butter and powder have less stringent flavour requirements, although post-harvest processing does affect the quality of the cocoa butter and sometimes the colour of the powder. It ought to be a conscious decision by a cocoa producer as to which market he is targeting, beans for cocoa liquor (taking into account the genetic and post-harvest considerations) or beans for butter and powder (with more flexible post-harvest processes). Appropriate quality training, standards, and a monitoring and enforcement scheme can then be adopted.

Moisture

Many cocoa quality problems arise from poor or inadequate drying of the beans. Fresh cocoa beans removed from the pod contain 40-50% moisture and this must be reduced to 8% or lower for efficient storage and transport. Drying can also impact on flavour development, with slower drying favoured as this allows acidity to decrease in the beans. It is inefficient to transport wet beans very far, and the presence of too much moisture can encourage mould (fungal) growth. Slow drying cocoa beans on a raised platform in the sun is best, but artificial drying using indirect sources of heat can also be used. Any contact with smoke or combustion products should be avoided. Drying beans properly will prevent many quality problems further down the chain.

Mould

Beans that have been taken from ripe intact pods and handled carefully through fermentation and drying should be free from internal mould. The presence of

Smallholder bean drying in Côte d'Ivoire. Beans are dried to ~8% moisture over 6-10 days depending on weather. They are covered with a plastic sheet at night or if it rains (Martin Gilmour)

sugary pulp around the bean and many post-harvest practices favour the growth of microorganisms on the outside of the shell, but the presence of mould on the inside of a bean indicates improper practice of some kind. Overripe pods may contain germinated beans which, when dried, allow moulds to get inside the shell. Beans damaged in some way, perhaps by opening the pod with a machete, can also develop internal mould. In general, proper drying to around 8% moisture inhibits mould growth. High levels of mould in cocoa beans affect fat quality and flavour, and can potentially give rise to mycotoxins.

Bean size distribution

Almost all cocoa beans are roasted during the production of cocoa liquor, butter and powder. This is necessary to develop cocoa and chocolate flavour. Other processes include heat treatment to loosen the shell, breaking the beans into fragments, and winnowing or removing the shell to leave the cocoa nibs. For these processes to run efficiently, it is important that the bean size distribution is as constant as possible. Manufacturers can adjust bean processing to take account of any size of bean, but a mixture of large and small beans in one batch leads to uneven roasting and high levels of waste. In general, larger beans are preferred because of the higher nibs:shell ratio.

Fat content and fat quality

Most cocoa beans (1.9 million tonnes) are processed into cocoa butter and cocoa powder. The butter is the more valuable food ingredient and therefore beans with a high fat content are generally more valued by the processing industry. The quality of the cocoa butter is important as the composition and crystallization properties of triglycerides determine the texture, hardness and melting properties of chocolate. High levels of free fatty acids (FFAs), which are the breakdown products of triglycerides, may cause quality problems in chocolate, and are an indication that cocoa beans have not been treated appropriately. FFAs are mostly generated by lipolytic enzymes from microorganisms, therefore high levels indicate a high level of beans that are broken, have not been dried properly or have been stored for a long time in inappropriate conditions.

Some farmers dry cocoa pod placentas (top) with beans and add them to bulk up volume in the hope of a bigger payment. The placenta is worthless and has to be (expensively) removed by the processor (Martin Gilmour)

Debris

During the journey from tree to cocoa-processing factory, sacks or lots of cocoa beans can pick up various kinds of debris. Flat beans, broken beans, pieces of placenta, fragments of pod, twigs and small stones may all find their way into the sacks before they leave the farm. In some regions, systematic addition of debris to cocoa beans has become almost routine. Clearly the presence of debris detracts from cocoa bean quality and requires additional effort later in the chain to remove non-cocoa rubbish from the beans before processing.

Quality in Transport

Cocoa is an excellent cash crop for smallholders in tropical regions. Unlike fresh fruit, rapid access to local or international markets is not necessary for a non-spoiling crop such as cocoa. Nevertheless, cocoa should not be stored at the farm level or even in the tropics as a whole for extended periods due to the moisture, mould and FFA problems described above.

Cocoa quality can be maintained by the rapid collection of properly fermented and dried beans from smallholders, followed by prompt shipment from the producing countries to the consuming regions. Ideally, the cocoa would be put into export bags as close to the farm as possible. Cocoa prepared properly should not have to be blended with cocoa from other farms or regions to create an 'average' quality. Most cocoa is still shipped in jute sacks, and it is important that these are made from food grade materials (see above). As cocoa is often shipped from hot humid countries to cool temperate countries, ventilated containers are preferred to reduce condensation during shipment. Possible insect infestations need to be controlled by approved fumigation procedures, and on arrival cocoa should be stored in warehouses dedicated for food storage.

Many of the quality issues linked to physical defects in cocoa could be eliminated if there was an outlet or alternative market for poor quality beans. It is not surprising that smallholders have a tendency to include all beans in the cocoa they sell to the middleman, especially if there are no robust systems to monitor bean quality. Poor quality beans (broken, flat, germinated, etc.) do have a value as cocoa butter can still be recovered, making some kind of two-track cocoa supply chain a possibility. It may be economically more sensible to separate poor quality beans at the farm level and get a lower price for these, rather than incur a discount on unsorted bean lots.

Farmer Organization and Training

Communicating with smallholders is essential as they are the vital first step in the chain leading to consumption. Getting quality right at the farm level must be a priority in an efficient supply chain. Mistakes and poor quality practices that occur here can only lead to sub-optimal quality cocoa being transported through the chain, and/or expensive and inefficient systems to correct the quality deficiencies further down the pipeline. Many quality issues could be addressed more efficiently if the smallholder production base was better organized. The current production system, involving millions of smallholders, presents a considerable challenge to communicating necessary changes in production practice. Fortunately there are signs that farmers are becoming more organized; the Sustainable Treecrops Program (STCP) in West Africa, for example, is helping cocoa farmer cooperatives to function more effectively. Farmer Field Schools, which use a participatory approach to communicate good husbandry and disease control practices, are now operating in West Africa and Indonesia. In some cases, training in dealing with a pest can lead to yield and quality improvements (e.g.: cocoa pod borer [*Conopomorpha cramerella*] control in Indonesia). Hopefully training on quality will become part of all cocoa sector initiatives involving capacity building in farmer organizations. A good start has been made by the ICCO (International Cocoa Organization) cocoa quality improvement project, which successfully trained farmers on quality (for liquor grade beans) during the 2003/04 season in Côte d'Ivoire.

Each step in the cocoa supply chain should add value or at least not detract from the quality of the cocoa beans. There is an opportunity for cooperatives to show they can add value by making sure the cocoa they market on behalf of their farmers is of good quality. This may help spread the responsibility for quality to the other participants in the chain, and reduce the need to blend good and poor cocoa lots to achieve an 'average' quality. As market participants in the sale of chocolate products compete with each other, it may be useful to encourage farmer organizations to compete, with quality as the main driver.

A Trend towards Total Quality?

The quality parameters described above are the basic criteria which have to be met for chocolate manufacturers to produce the good quality chocolate demanded by millions of consumers worldwide. Other niche products, e.g. organic, will have additional quality criteria based on certification of soil and inputs. In the future other criteria, e.g. environmental and social impact, may come together to form a concept of 'total quality' and it is also worth noting that the EU is encouraging steps towards greater traceability of food raw materials, stimulated at least in part by recent food scares. Traceability in the complex cocoa supply chain as it currently exists with millions of smallholders and many middlemen would be extremely difficult to achieve. Some movement towards a form of ethical certification in West Africa can be seen in the process underway between the cocoa-using industry and cocoa-producing country governments in this region, helping them develop a certification process for labour standards in cocoa production.

Quality is fundamental if we are to satisfy consumers and fuel the engine which maintains a sustainable cocoa economy. Poor quality raw materials mean a poor product and a potential loss of consumer confidence in a brand. It is the responsibility of everyone in the chain to maintain, or add value to, that part of the pipeline in which they operate. Quality standards and monitoring will get more demanding, driven by consumer expectations and regulatory authorities in consuming societies. All cocoa pipeline stakeholders in a sustainable cocoa economy must communicate this message about quality, however unpopular. It is only by safeguarding quality and delivering products that meet consumer needs, that we will ensure a sustainable future for cocoa consumption and so contribute to the sustainability of rural livelihoods for millions of smallholder cocoa farmers around the world.

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Trinidad & Tobago: a Heritage of Fine Quality and Flavour

Trinidad & Tobago is an exclusive producer of fine or flavour cocoa and is regarded as the centre of origin for Trinitario germplasm. When optimally processed, cocoa from Trinidad & Tobago possesses interesting fruity, mildly floral, winey, even raisiny overtones that are quite distinct from those found in bulk cocoas. These flavour attributes are sought after by certain manufacturers of premium chocolates. This demand provides a market environment in which the price for cocoa from Trinidad & Tobago is well above the international market price for bulk cocoa.

In general terms, different aspects or specifications of quality in cocoa include flavour, purity (lack of infestation or disease), consistency in bean size and moisture content, yield of edible material and cocoa butter characteristics. These are the key criteria affecting a manufacturers' assessment of the 'value' of a particular parcel of beans and the price they are willing to pay for it.

The quality and flavour of cocoa from Trinidad & Tobago represents a unique blend of a number of factors, including the planting material, local environment (climatic and edaphic), and post-harvest processing methods. All these factors affect the flavour potential of the dry beans, from which specialist chocolate manufacturers make liquor to exploit the fine Trinidad & Tobago flavour.

When one examines each influence in turn, the holistic nature of quality becomes apparent. The Trinitario germplasm, which literally means 'native of Trinidad', originated from natural hybridization between remnants of Criollo germplasm introduced into Trinidad in the 16th Century by the Spanish and the Forastero varieties from South America, introduced in the 18th Century. This occurred after the original material was destroyed by a mysterious 'blast' in 1727.

Selection and breeding programmes have spanned over 60 years. In the 1930s F.J. Pound carried out an extensive survey of cocoa in Trinidad & Tobago from which he selected the best 100 clones, the well-known Imperial College Selections (ICS). Subsequently, W.E. Freeman at the Ministry of Agriculture (now Ministry of Agriculture, Land and Marine Resources [MALMR]) spent over 30 years developing the Trinidad Selected Hybrids (TSH) in an ambitious recurrent selection breeding programme. The TSH cultivars are renowned for fine or flavour attributes, and TSH 919 in particular has been described to have an 'aristocratic' flavour. With appropriate agronomic inputs, the TSH cultivars are noted for their high yield (>2,000 kg/ha), large bean size and low pod index. The breeding programme in MALMR is on-going, with further selections being made for superior yield, disease resistance, environmental adaptability and to maintain fine flavour potential for the export market.

Turning beans in fermentation sweat boxes at the San Juan Estate, Gran Couva, Trinidad (D.A. Sukha)

Optimal post-harvest processing exploits the flavour potential of the Trinitario germplasm and it is of interest therefore to examine the traditional fermentation and drying procedure employed by large estates - methods still recommended for farmers in Trinidad & Tobago today.

Traditional Methods Favour Flavour

Ripe pods are usually harvested from Monday to Thursday, heaped in the field and cracked open on Friday. They are sorted manually to remove diseased beans and placentas. The selected beans are transported to the fermentation facility and placed in double-walled sweat boxes for fermentation. Boxes are typically made of cedar with slatted floors and have a capacity of some 2000 kg of wet beans. Dried mucilage left after fermentations is removed from in between the floor slats but allowed to accumulate on the inside walls since it serves as a source of microflora for successive fermentations and also to inoculate new sweat boxes. The top of each box is covered with banana leaves and jute sacks before the wooden lid is put in place to initiate the fermentation process. The beans are turned on the 2nd and 4th days and care is taken to mix them thoroughly and to break up large agglomerates. Fermentation usually lasts 6-8 days, the exact duration being determined by the external and internal appearance of the beans. Next, the beans are spread out to dry on wooden floors in specially constructed 'cocoa houses'. The drying rate is slow for the first 2-3 days and the beans are left in heaps overnight

Sun drying in "cocoa houses" at the San Juan Estate, Gran Couva, Trinidad (D.A. Sukha)

for the first 2 days. On the drying floor, the beans are mixed periodically with wooden rakes to ensure even drying. After being sun-dried, the beans are polished. Traditionally this is done either by 'dancing the cocoa', regarded as a special social activity or, more commonly today, with a mechanical agitator. Drying continues until the final moisture content of 7-8% is reached, after which the cocoa is graded and bagged.

The end result of optimal expression of the flavour potential of the Trinitario germplasm with careful processing is a high-quality product, a price premium and a niche market status. Perhaps the best local example of the success contributed by each step in the processing chain is the San Juan Estate in Gran Couva, central Trinidad. There, the unique interplay of the predominantly ICS germplasm, the rich 'chocolate' soils of the Montserrat Hills, careful fermentation and gradual drying combine to give a premium quality bean used to make an origin-specific chocolate of high acclaim. 'Gran Couva chocolate' is arguably one of the most exclusive in the world.

Maintaining Excellence in a Changing World

The tradition of excellence in cocoa in Trinidad & Tobago extends into the realm of research. Pioneering collaborative research on cocoa fermentation and drying involving quality and flavour chemistry was undertaken at the Cocoa Research Unit (CRU) and MALMR in the 1960s and early 1970s. This work formed the basis of subsequent studies on this subject in various research centres around the world. Investigations were re-initiated at CRU in 1995 to examine quality assessments in relation to fermentation and drying of selected Trinitario varieties. Current work includes investigations into environmental effects and the effect of pollen donor on flavour and comparisons of the flavour of individual clones.

From its inception in the 19th century, the cocoa industry in Trinidad & Tobago was plantation based; however, social, economic and political factors have changed its structure since the 1960s. Today the majority of cocoa is produced by farmers with smallholdings in mixed cropping systems, and only a few large plantations still operate. Individual small farms typically produce less than 1000 kg of dry cocoa per year, which is too little to ferment in traditional sweat boxes. This has prompted a drive to establish central fermentaries where the quality associated with plantation production can be maintained. Recent initiatives have demonstrated the economic viability of medium-sized holdings operating an intensive cocoa production system using TSH varieties. It is likely that this type of system could be the key to the future of the cocoa industry in Trinidad & Tobago.

The widespread adoption of TSH varieties in the twin islands probably explains the low incidence of witches' broom disease (caused by *Crinipellis perniciosa*) currently found in farmers' fields and the virtual elimination of *Ceratocystis* wilt disease in the last 20 years. Losses due to black pod disease (caused by *Phytophthora* spp.) remain substantial, however, and further development of the TSH germplasm is being undertaken to address this problem. A new TSH series (1300 series) is currently being evaluated in field trials by MALMR, but new varieties will not be selected for release to local farmers until final assessments of flavour have been completed.

One can see that the cocoa industry in Trinidad & Tobago has changed with the passage of time. Nevertheless, appropriate steps are constantly being taken to keep abreast of these changes whilst retaining our enviable position as an exclusive producer of fine or flavour cocoa. The rich history and good reputation for high quality cocoa and excellence in cocoa research is of great importance to our small country.

Quality starts with the selection of suitable germplasm grown in the appropriate environment. Optimal primary processing realises the flavour potential of the germplasm used, this continues through to secondary and further processing. Therefore, all parties in the 'cocoa chain' have their part to play in ensuring that consumers of premium chocolates made from Trinidad & Tobago cocoa are provided with a product that is safe, wholesome, full of flavour and a most enjoyable experience.

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Identifying, Measuring, Producing and 'Selling' Quality Attributes

'Quality' in tree crop products is not a simple concept, and improving quality for the benefit of smallholders can be a real challenge. It is to address this issue that CIRAD[1] is coordinating a research programme focused on the 'Improvement of cocoa quality for the benefit of cocoa producers'.

Challenges to Improving Bean Quality

If tree crop products are to realise their potential contribution to sustainable development and to poverty alleviation amongst smallholders, then some of their characteristics must change to meet evolving quality demands of consumers and end users.

However, tree crop producers must overcome a number of obstacles to reach this goal. For instance, they are often not aware what quality attributes are required by the end users (they may even be ignorant of how their product is 'consumed'!); they do not know how to control, or if necessary eliminate, the development of specific characteristics; some of the attributes, such as flavour, are difficult to assess, and may even be impossible to measure on-farm; and the economic incentives offered are often insufficient to compensate farmers for the investment they have to make to obtain a product with such specific characteristics.

For various reasons, the obstacles to qualitative adaptation are especially high for a perennial tree crop such as cocoa: because most of the crop is usually exported, a big physical and cultural 'gap' has emerged between the production and consumption zones; successive stages in a processed crop such as cocoa (unlike fresh produce) are accompanied by changes in quality criteria along the chain (which sometimes do not tally with users' requirements); a multiplicity of middlemen between producers and consumers mean discontinuities in responsibility for processing and handling the product; there is a growing consumer demand for quality, notably with the emergence of health and environmental constraints (affecting especially crops of the equatorial forest zone), and ethical concerns.

The perennial nature of the cocoa crop means there is a good degree of consistency in the qualitative characteristics of the product from one harvest to the next, with an ensuing risk of quality attributes not receiving the remuneration they deserve. Indeed, it has been noted that the quality premiums paid for tree crop products are relatively smaller than those attached to annual crops, since producers of annual crops can more easily switch from one variety (or crop) to another if they judge the incentive to be insufficient. But this handicap may be partially compensated for by the strong relationship between a tree crop product and its origins - the place where it was grown or '*terroir*' - which offers an opportunity for cashing in on the territorial image of cocoa.

Studying Consumer Behaviour

It may seem surprising that a research institution like CIRAD, whose aim is to promote sustainable development in tropical countries, has to study the behaviour of European chocolate consumers, far away from the cocoa-producing countries. In itself, this approach testifies to the interdependence of all stakeholders in the cocoa chain, from producers to consumers. It is also the only way to try to give accurate advice to cocoa farmers' associations interested in cashing in on expanding diversification in cocoa/chocolate consumption, and more precisely on the growing demand for cocoa with specific quality attributes such as organic, fair-trade, bird-friendly or single-origin.

A number of questions have to be answered before it is safe to recommend to cocoa producers a move into the production and commercialization of these types of cocoa:

- Is the growing demand for such speciality cocoas a lasting trend, or only a transient fashion?
- What are the social, cultural, and economic bases of this new consumer behaviour, and are these characteristics restricted to a small 'niche' of consumers or are they, at least partly, shared by a larger population of chocolate eaters?
- How much are consumers willing to pay for organic/fair-trade/single-origin chocolate, and what happens when a product merges two labels (e.g. organic *and* fair-trade)?
- How can we be sure that some of the premium paid by consumers actually filters through the distributors, the chocolate manufactures, the traders and the certifying agencies, to reach the cocoa producers themselves?

It is to answer these questions (and many others) that a research programme involving a Togolese student studying for a PhD in Economics was launched 2 years ago in Montpellier. In particular, two trials aiming to understand consumers' behaviour and establish their willingness to pay for speciality chocolates have been designed and executed. Statistical analysis of the data is still underway but some preliminary observations can be made.

In the first trial, 150 chocolate consumers (but not cocoa/chocolate specialists) were asked to simply rate their appreciation of 8 chocolates, based only on sensory evaluation (no information was provided on the brands, labels, cocoa content, price…). The products were all dark chocolate (cocoa mass content 60- 70%) sold in the Montpellier region, 4 of them as organic and/or fair-trade.

Overall trends indicate that 7 out of the 8 chocolates received, on average, a favourable rating ('good' or 'very good'). Women gave better ratings overall, with men over 45 years old being the most severe in all categories. Organic and/or fair-trade chocolates were, on average, considered less pleasing than non-certified ones, but one organic and fair-trade chocolate was well received and ranked with the non-certified chocolates.

The second trial was more complex: 100 people who regularly buy chocolate were invited, in groups of 5-10, to evaluate 4 products. The evaluation was carried out in a stepwise manner, with or without information on the products, and with or without the opportunity to taste them. At each step, people were asked to note (confidentially) the price they would be willing to pay for the product. The test was carried out following recommended marketing research procedures to ensure that people's behaviour was as similar as possible to that exhibited when buying in a shop. The 4 chocolates were selected from the 8 used in the first trial and presented in an anonymous chocolate wrapping, with various levels of information. This evaluation was followed by an individual interview with each participant.

Preliminary results indicate that consumers of organic products and of fair-trade chocolate do not share identical behaviour, but in both cases it is important to note that they consider the sensory quality of the chocolate to be a prerequisite. This means that people buy a chocolate first because they like it, and that other criteria are of secondary importance to overall appreciation. Sensory appreciation of the chocolate remains the prime determinant of consumers' willingness to buy a product, and their willingness to pay for it! This is confirmed by the observation that the range of price differentials (premiums offered) appears to be higher when people are able to taste the chocolates than when they are asked to suggest a price based only on the information displayed on the wrapping.

Consumers of organic products appear concerned about their own health, about the flavour of the chocolate and about the impact of cocoa production on the environment. Fair-trade consumers wish to express (in various ways) their sense of solidarity with the cocoa producers. Otherwise, both types of consumers share the same cultural and social values, which means that the still-small fair-trade chocolate market has the potential to expand into the relatively larger organic chocolate market.

A tasting session: even for certified chocolate, people choose first on the basis of sensory quality (P. Bastide, CIRAD)

Questions and Hypotheses

CIRAD's cocoa quality research programme focuses on *terroirs* and commodity chains and its approach is constructed around four components:

1. Economic analysis of demand: what are the quality attributes of cocoa beans and cocoa products that are recognized on the local or export market, and which of them can be exploited to the benefit of producers?
2. Understanding the biological and technological mechanisms influencing product characteristics: what are the determinants of these attributes?
3. Development of tools to assess and monitor those characteristics: how can these attributes be measured, easily and cheaply?
4. Implementation of this knowledge into quality improvement focused strategies for the sustainable development of the tropics.

The purpose is to provide the *knowledge*, *tools*, *methods*, *expertise* and *know-how* that are:

1. Adapted to the specifics of cocoa production, marketing and consumption.
2. Required for cocoa production to adapt to increasing quality demands, and notably, to offer users guaranteed product characteristics.
3. Geared towards ensuring that this qualitative evolution benefits all stakeholders in the commodity chain but primarily the cocoa smallholders (a win-win situation).

On-going collaborative projects between CIRAD and partners around the world illustrate this approach to tackling the challenges to cocoa quality improvement.

- *What are the quality attributes sought by users and consumers? How has that demand evolved over time? What are the medium-term trends?*

Examples include studies of consumers' willingness to pay for organic, fair-trade and single-origin chocolate in France (see Box), and of the development of fair-trade chocolate in the UK.

- *What mechanisms lie behind these quality attributes?*

Examples include investigating the role of genotype, post-harvest technologies and environment on the flavour of cocoa beans, in both bulk cocoa and fine-flavour cocoa (Criollo, Nacional, Trinitario…); and QTL (quantitative trait loci) studies on bean size and fat content.

- *In particular, what contaminants are found in perennial tree crop products and how do they get there?*

Examples include: identification of the causes of high OTA (ochratoxin A) levels in cocoa beans, especially in West Africa; factors affecting FFA (free fatty acids) in cocoa beans from Côte d'Ivoire; identification of contamination sources (mycotoxins, impurities, pesticides) and development of preventive solutions (including chemical-free disinfestation of stocks).

- *How can quality attributes be measured in a reliable, transferable and inexpensive way?*

Ongoing work includes use of global analysis of spectral fingerprints by NIRS (near infrared spectrometry) and SPME/MS (coupled solid phase micro extraction and mass spectrometry) for the development of rapid, reliable analytical methods, including 'on-line' systems; development of reference databases; analytical tools for certification of origins; improvement of methodologies for statistical analysis of sensory data.

- *How is it possible to cash in on the quality attributes identified and measured?*

Several 'on the ground' projects are based on technological innovations and commodity chain organization to take maximum advantage of qualitative changes in demand for cocoa beans. Work focuses on producers' organizations, since they can play a decisive role in promoting these quality attributes to the benefit of the cocoa smallholders. Specific interest is also given to the development of quality indicators (or 'labels') and of specification systems (notably for certification).

Ongoing work includes: production of organic and/or flavour cocoa beans in São Tomé, Ecuador and the Dominican Republic; transfer of technologies (Farmer Field Schools) and support to farmers' organizations in Ecuador; development of training modules for stakeholders in the commodity chain (including for small-scale chocolate manufacturers).

[1]CIRAD is the French Agricultural Research Centre for International Development; its mandate is to "contribute to the sustainable development of tropical and subtropical countries through research, experimentation, training and scientific and technical information"

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Biodiversity Conservation and Cocoa Agroforests

Biodiversity - the sum total of life on Earth - has a profound and far-reaching importance, from the inherent value of the great diversity of species in their natural habitats, to the cultural, medicinal, nutritional and economic benefits provided by individual species, to the invaluable role played by natural systems in generating ecosystem services such as controlling erosion, cleansing the air and water, storing carbon, enriching soil, and pollinating crops, which maintain the quality of our environment. Despite these considerations, the world's biodiversity is under threat as deforestation of tropical forests located in major biodiversity hotspots proceeds. Hotspots are areas that harbour more than 60% of the global biodiversity in endemic species that are, however, under severe threat of extinction. Slash-and-burn agricultural practices are one of the main contributors to deforestation in these areas. Agroforestry, where crops are cultivated in association with trees, is often seen as a more socially, economically and environmentally sustainable approach. In this article, we describe how agroforestry systems based on cocoa can contribute to conserving biodiversity in hotspots and thus preserve the quality of some of the world's most important natural areas. In addition, we show how a project, designed to promote the protection of biodiversity in Ghana, strengthened sustainable cocoa-based livelihoods and thus the quality of life in the area.

Cocoa, one of the world's most important commodities, is grown on over 7 million hectares. The cocoa-cultivated lands are mainly located in tropical biodiversity hotspots. Although the expansion of this crop often occurred at the expense of forests, its cultivation is environmentally preferable to many other forms of agriculture. This is because cocoa, an understorey tree, has been traditionally cultivated under the shade of native canopy trees within agroforestry systems that maintained to some extent the original forest cover. Cocoa agroforestry systems are considered to have the potential for supporting greater biodiversity than other tropical production systems, particularly annual crops and cattle pasture. Furthermore, cocoa agroforests often include other tree species of economic value, which can reduce farmers' risks connected with growing a single crop[1]. By promoting diversified production systems that incorporate natural processes and local available resources, agroforestry systems offer also greater prospects for sustainable local development.

Farmers collecting data for field trials during the Farmer Field School, which enhanced farmers' planning and problem-solving skills in finding locally appropriate agricultural solutions (Todd Hamner)

Côte d'Ivoire and Ghana are both located in the Upper Guinea Forest of the Guinean Forests hotspot. This forest contains several endemic species and more than half of the mammalian species in Africa, including the endangered *Cercopithecus diana* (Diana monkey) and *Loxodonta africana cyclotis* (forest elephant). These two countries together produce almost 60% of the world's cocoa. However, increasing adoption of unsustainable cocoa farming practices is posing a threat to local biodiversity. To boost short-term yields, farmers have been moving away from traditional shade cocoa to more intensified production systems without or with reduced levels of shade. These practices reduce not only on-farm biodiversity, but also its long-term sustainability, as nutrients in the exposed soil leach out and farms become progressively susceptible to declining yields. They also become more prone to insect attack and disease spread, which further reduces cocoa productivity. Farmers are responding to the declining yields by expanding production into forest areas or converting their cocoa farms to maize or cassava, all of which have negative environmental impacts. The clearing of additional forest areas increases the level of forest fragmentation, making the interaction between populations more difficult, and, therefore, reducing the chances for the long-term survival of species.

To tackle this problem, Conservation International (CI), with financial support from the US Agency for International Development (USAID), began a Conservation Cocoa Agroforestry Project in 2000 in areas around Kakum National Park in Ghana's Central Region. CI partner organizations in this project included the Cocoa Research Institute of Ghana (CRIG) and the Ministry of Food and Agriculture (MOFA).

Farmers' meetings within the Farmer Field School provided a forum for discussing the strong link between cocoa productivity and biodiversity conservation (Todd Hamner)

This project aimed to reduce pressures on the remaining forests of the Kakum National Park by improving the productivity of existing farms located in the buffer zone of the Park by promoting cocoa agroforestry best practices. Cocoa agroforests close to forest areas provide effective habitats for some species dispersing between forest patches. The agroforestry systems created by this project would not only improve the quality of life of farmers but also contribute to the creation of the Southwest Ghana/ Southeast Côte d'Ivoire Conservation Corridor. Conservation corridors connect isolated forest fragments in a landscape by establishing biodiversity-friendly land uses such as cocoa agroforestry. By creating such a corridor, interactions between species' populations are improved, which enhances the chances of the long-term survival of biological communities and ensures the maintenance of large-scale ecological and evolutionary processes [2].

CI employed Farmer Field School (FFS) participatory extension methodology during the project to facilitate farmers' learning about locally appropriate cocoa agroforestry practices. A draft FFS curriculum was developed during a workshop where farmers and researchers jointly compiled farming practices and research recommendations into cocoa agroforestry best practices. From 2001, the project validated the curriculum through the FFS. During the FFS, farmers could identify the practices that work best under their local conditions by testing agroforestry practices drawn from their own knowledge and from research findings. Besides working at the farm level, other crucial aspects in the promotion of agroforestry systems were incorporated, such as strengthening the organizations that provide extension services to farmers and fostering policies to support the implementation of cocoa agroforestry best practices.

By the time the project finished at the end of 2003, significant progress had been made. At the farm level the project successfully trained 400 farmers in cocoa agroforestry best practices. A survey indicated that 40% of them had started implementing at least 50% of the recommended practices on their farms. By promoting the effective adoption of low-input technologies and practices that increase long-term productivity, the project improved farmers' incomes and the quality of their environment. In addition, farmers developed better environmental awareness from group discussions on the relationships between forest cover and productivity factors such as rainfall and soil fertility. Farmers also improved their understanding of ecological interactions at the farm field level, particularly of pests, diseases and beneficial insects.

At the institutional level, CI and partners strengthened the farmer organization Kuapa Kokoo, and the MOFA extension services through training of extension agents in the participatory approach. In addition, the organizational capacity of Kuapa Kokoo was improved by training of officers and compiling a Society Training Manual. The awareness of political decision makers from local and national institutions on the value of promoting sustainable cocoa production systems was also enhanced.

At the market level, CI strengthened Kuapa Kokoo by investing in its UK-based fair-trade manufacturing arm, the Day Chocolate Company, which enables farmers to share the profits from added-value consumer products.

In conclusion, the revitalization of cocoa agroforestry systems in Ghana has provided a great opportunity for bringing together different parties interested in creating a sustainable future for the cocoa production sector. This successful approach is expected to be replicated in the biologically rich southwest area of Ghana, using experience in developing agroforestry projects accumulated by CI. To facilitate this, a supportive network of investments, policies, institutional support, and partnerships with policy makers, the scientific community and the private sector is being developed by CI with support from the Global Environmental Facility.

[1] Rice, R.A.; Greenberg, R. (2000). Cacao cultivation and the conservation of biological diversity. *Ambio* 29(3), May 2000.

[2] Center for Applied Biodiversity Science, Conservation International & Institute for Social and Environmental Studies of Southern Bahia (2000). *Designing Sustainable Landscapes. The Brazilian Atlantic Forest*. Publ: Conservation International Center for Applied Biodiversity Science.

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