UNIVERSITI PUTRA MALAYSIA

# CHARACTERISTICS OF MALAYSIAN AND SULAWESIAN COCOA BEANS AND THE OPTIMISATION OF QUALITY THROUGH BLENDING

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# CHARACTERISTICS OF MALAYSIAN AND SULAWESIAN COCOA BEANS AND THE OPTIMISATION OF QUALITY THROUGH BLENDING

By

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Abstract of the thesis presented to the Senate of Universiti Putra Malaysia in fulfilment of the requirement for the degree of Master of Science.

**CHARACTERISTICS OF MALAYSIAN AND SULAWESIAN COCOA BEANS AND THE OPTIMISATION OF QUALITY THROUGH BLENDING**

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August, 1999

**Chairman** : **Professor Jinap Selamat, PhD**

**Faculty** : **Food Science and Biotechnology**

Commercial Malaysian and Sulawesian cocoa were found to be significantly different ($p<0.05$) in the aspect of bean quality, fermentation index, fat content, polyphenol, alkaloids, volatile and non volatile acids. In other aspects such as melting point (cocoa butter), triglyceride, fatty acids and solid fat content (SFC) the difference was found to be insignificant ($p>0.05$). More purple bean was found in the Sulawesian beans (78%) compared to the Malaysian beans (4%). The high content of polyphenol (epicatechin = 34.72 mg/g) and alkaloids (theobromine = 30.40 mg/g, caffeine=0.678 mg/g) in Sulawesian beans showed a sign of under-

fermentation. Fermentation index further verify Sulawesian beans (0.622) as under- fermented compared to the Malaysian beans (1.524). Cocoa beans with different fermentation level exhibited significant difference in cut test, melting temperature (Malaysian beans only), volatile and non-volatile acid, polyphenol, alkaloids, solid fat content and taste. Melting temperature of the Malaysian cocoa butter increase with fermentation. Non-volatile acids such as lactic, succinic and citric increased but malic and oxalic acids decreased with fermentation. All the volatile acid but propionic acid increased with fermentation. On the other hand, polyphenol and alkaloids decreased drastically as fermentation proceeds. In the aspect of taste, all less fermented cocoa beans from Malaysia and Sulawesi were more bitter and astringent but the more fermented cocoa beans produces cocoa liquor with a more sour taste. The qualities that the blended cocoa beans needs to express are a better cocoa/chocolaty taste, less bitter, less astringent, less sour and preferably with the presence of nutty flavour. Cocoa blends found to have the most favourable taste are blends of 4 days fermented Malaysian cocoa beans and 2 days fermented Sulawesian beans at the ratio of 75:25 (I2M4/25) and blends of 6 days fermented Malaysian cocoa beans and 2 days fermented Sulawesian beans at the ratio of 25:75 (I2M6/75).

Abstrak tesis yang dikemukakan kepada Senat Universiti Putra Malaysia sebagai memenuhi keperluan untuk ijazah Master Sains

# CIRI-CIRI KOKO MALAYSIA DAN SULAWESI DAN OPTIMISASI KUALITI MELALUI CAMPURAN

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Koko komersil dari Malaysia dan Sulawesi menunjukkan perbezaan ketara ($p<0.05$) dari segi kualiti biji, indeks fermentasi, kandungan lemak, polifenol, alkaloid, asid meruap dan tidak meruap. Aspek lain seperti takat lebur (mentega koko), trigliserida, asid lemak dan kandungan lemak pejal tidak menunjukkan perbezaan yang ketara ($p>0.05$). Lebih kotiledon yang bewarna ungu dikesan dalam koko Sulawesi (78%) dibandingkan dengan koko Malaysia (4%). Kandungan tinggi polifenol (epikatekin=34.72 mg/g) dan alkaloid (thiobromin=30.40 mg/g, kaffein=0.678 mg/g) dalam koko Sulawesi memberi petanda bahawa ia tidak difermentasi dengan sempurna.

Index fermentasi juga menunjukkan bahawa koko Sulawesi (0.622) kurang difermentasi banding dengan koko Malaysia (1.524). Biji koko yang mempunyai tahap fermentasi yang berlainan menunjukkan perbezaan yang ketara dari segi ujian keratan, takat lebur (koko Malaysia sahaja), asid meruap dan tidak meruap, polifenol, alkaloid, kandungan lemak pejal dan rasa. Takat lebur bagi mentega koko Malaysia didapati meningkat dengan fermentasi. Asid tidak meruap seperti asid-asid laktik, suksinik dan sitrik meningkat tetapi asid malik dan oksalik menurun dengan fermentasi. Semua asid meruap kecuali asid propionik meningkat dengan fermentasi. Di samping itu, polifenol dan alkaloid menurun dengan ketara dengan peningkatan tahap fermentasi. Dari segi rasa, semua koko yang kurang difermentasi dari Malaysia dan Sulawesi adalah lebih pahit dan kelat tetapi koko yang mengalami tahap fermentasi yang lebih lama didapati lebih masam. Kualiti yang perlu ditonjolkan oleh koko campuran adalah rasa koko/coklat yang lebih baik, kurang pahit, kurang kelat, kurang masam dan sebaik-baiknya dengan kehadiran rasa kacang. Campuran koko yang mempunyai rasa y ang terbaik adalah campuran dari koko Malaysia yang difermentasi 4 hari dengan koko Sulawesi yang difermentasi 2 hari pada nisbah 75:25 (I2M4/25) dan campuran dari koko Malaysia yang difermentasi 6 hari dengan koko Sulawesi yang difermentasi 2 hari pada nisbah 25:75 (I2M6/75).

# CHAPTER I

# GENERAL INTRODUCTION

## Background

Cocoa trees originated from the American tropics in the region of the Amazon and belong to the genus *Theobroma*. *Theobroma* cacao belongs to the family Sterculiaceae. Linnaues gave the cocoa tree its name in the first edition of his 'Species Plantarum' published in 1753. In 1964 Cuateccasas further divided the genus into 6 groupings containing 22 species of which *Theobroma* is the only species of commercial value. Other better known species in the genus are *Theobroma bicolor* and *Theobroma grandiflorum*. *T. Bicolor* is atypical of the genus as its inflorescence appears in the axils of the new leaves. It's large heavy pods are borne on the ends of the branches, which bend downwards when the pods reach maturity. The beans have white cotyledons and in size are similar to small cocoa beans known as 'pataste'. They are used as an adulterant of cocoa in Central America. *Theobroma grandiflorum* also known as 'Cupuacu' in Brazil is well liked locally for the delicate flavour of the mucilage around the bean (Woods and Lass, 1985).

The growth parameters required by cacao trees are fairly precise. The areas of cultivation lie within the rain forest regions of the western

hemisphere from 18°N to 15°S latitudes of the equator. The suitable temperature range for it's growth is around 21°C - 32°C accompanied by rainfall of about 1,150 mm - 2,500 mm per year. In countries with defined wet and dry season, the main harvest of cocoa will be obtained 5-6 months after the start of the wet season (Bridgland, 1953).

Among the subspecies of the species *Theobroma cacao*, only 2 of them are of any commercial value. Those are the Forestero and the Criollo, and it includes a cross between the two which is the Trinitario (Wood and Lass, 1985). The physical and chemical characteristics of these two cocoas differ significantly even though they are from the same genus. The Criollo subspecies are found mostly in the populations of Central and South America and the Forestero subspecies are found in all the other populations.

Cocoa in Malaysia originated from the Amazon region in Latin America and was known to have reached Sabah as early as 1700. Cocoa was first observed in Malaysia in the year 1778 in Malacca. In the year 1882, a 20 years old cocoa tree was observed to be fruiting well in Sabah, which was then known as British North Borneo (Anon, 1996a).

The cultivation of the cocoa tree first started as an experiment at the then Agricultural Research Station in Serdang and also at the Agricultural Experimental Station in Silam, Sabah. Serious cultivation of the cocoa did not start until the end of the second world war, when the government was looking for a crop to supplement the contribution of rubber. As a result, in 1950, seedlings from West Africa, mostly of the Forestero type, were imported and tested in the volcanic soils of Tawau, Sabah and also in the Tarat Research Station in Sarawak (Wyrley-Birch, 1976). The first commercial estate was established in 1950 at Jerangau, Trengganu followed by the estates of the Borneo Abaca Ltd company in Sabah in 1955.

Commercial planting of cocoa in Malaysia commencing in the 1950's, saw expansion in the late 1970's and early 1980's due to the high prices fetched by cocoa beans. However, world production of cocoa beans have been declining from the early 1980's caused by a drastic drop in cocoa prices due to over supply. Given the scenario, decrease is anticipated in both planted areas and the production of cocoa at marginal rates of 1.4% and 1.8% per annum respectively in the period of 1991-2010 (Ministry of Agriculture, 1992).

Currently, Malaysian cocoa faces problems of quality and of relatively high production costs, due largely to labour shortages and the associated escalation in labour costs. Other additional factors that have

contributed to the closure of estates are the problem of insect infestation, particularly cocoa pod borers, and also competition from other more profitable crops such as oil palm and coconut. The recent and ongoing East Asian economy crisis might trigger a comeback of Malaysian cocoa production, given that cocoa is traded in U.S. dollars. But the process of replanting the cocoa trees takes time. Even then, other more profitable crops will outweigh the 'push' for increasing the area under cocoa cultivation.

Cocoa in Indonesia was mainly cultivated in estates, but from the year 1924-1929, an increase in smallholders production was noted (Fadhil and Darmawan, 1994). Increased cocoa production in the 1970s, in Indonesia has also contributed to the increase in world cocoa production. Indonesia has a long history as a cocoa producing region. Beans from Indonesia, in particular from Sulawesi, were usually not fermented or under fermented, since fermentation of cocoa beans is not a common practice among local farmers there. These beans, when used to produce cocoa liquor, of low quality. The flavour will not be fully developed and the presence of extreme bitterness will be detected. These beans are known to produce lower quantity of butter in comparison to the fully fermented ones. Sulawesian beans also pose problems to grinders. The lower cocoa butter content can give rise to poor flow properties during grinding.

Cocoa in Indonesia is produced largely from small holders. They accounted for about 70% of the cultivated cocoa area and 60% of the cocoa production in 1993 (Fadhil and Darmawan, 1994). The rapid expansion of cocoa plantations in Indonesia was due largely to the international competitiveness, the support of the government in distributing high yielding seeds, the availability of fertile land and the spontaneous migration of its people (Fadhil and Darmawan, 1994). Since 1992, Indonesia has maintained its position as the world's fourth largest cocoa producer.

In the last 7 years, the area brought under cocoa cultivation in Indonesia have shown a significant increase with the south and southeast Sulawesi accounting for 20% of the total cocoa area planted. The planted areas in North Sulawesi account for another 14%. The centers of the cocoa cultivation in Indonesia, which were dominated by the North Sumatera and East Java regions have now been shifted to south and south east Sulawesi. In Indonesia, cocoa cultivation is still profitable due to the low cost of labour and land. Hence, cocoa production in Indonesia is still on the increase.

**Significance of this study**

A tremendous amount of efforts has been made to improve the quality of Malaysian beans. It is hence discouraging to know that cocoa cultivation in Malaysia is diminishing. The decreasing supply of cocoa beans are attributed to the problems mentioned aforehand. Thus, it is opportune to source other means of obtaining good cocoa beans. Importing cocoa beans from other countries is one such possibility but the cost of obtaining good quality cocoa beans may prove to be too high. Sulawesian cocoa beans being un- or under fermented are of inferior quality to Malaysian beans. It can however be improved upon. If such efforts are successful, these cocoa beans may be used to produce more economical cocoa based products.

It is known that fermentation improves the flavour qualities of cocoa beans. It also improves the appearance of cocoa beans. Besides fermentation, genotypes also play an important role in the flavour quality of cocoa beans. The fermentation period of the cocoa beans is dependent, in some cases on the genotype as well. Therefore, the objectives of this study were:

a) To determine the physico-chemical qualities of commercial Malaysian and Sulawesian cocoa beans using Ghanaian beans as a standard.

b) To determine the physico-chemical qualities of Malaysian and Sulawesian cocoa beans under controlled fermentation periods namely 0, 48, 96 and 144 hours.

c). To determine the physico-chemical qualities of blended cocoa liquor and the best blending combination based on physico-chemical qualities and sensory requirements.

# CHAPTER II

# LITERATURE REVIEW

## Introduction

Cocoa bean quality is dependent on factors such as genetics, environment physiology and process technology (Biehl *et al.*, 1990). These three factors tend to vary bean quality in the different producing countries primarily due to tradition and circumstances. Thus, cocoa beans from different producer countries vary in flavour. This study mainly focused on the process technology especially the effect of fermentation on cocoa flavour.

## Harvesting

Cocoa pods take 4-5 months to grow to full size following pollination (Seeschaaf, 1971). The pods are then left on trees to ripen for about a month before harvesting. Composition of the cocoa pulp and its cotyledon (Table 1 & 2) depends on a few factors such as genotype, maturity and also environmental factors. During ripening the mucilaginous pulp surrounding the beans undergoes certain chemical and physical changes critical to successful fermentation (Ostavar and Keeney,

1973). On harvesting, the ripe pod is removed from the tree by cutting the peduncle to avoid damaging the tree. As all the pods on a tree do not mature simultaneously, the farmer must make repeated passes through the cocoa field to gather ripened pods. Premature harvesting will result in inferior beans. On the other hand, a prolonged delay in harvesting may result in beans germinating inside the pods (Shaughnessy, 1992). Using Malaysian beans, Lewis and Lee (1985) have demonstrated that the time of harvesting and pod storage are two major factors affecting chemical qualities associated with cocoa flavour. Mac Lean and Wickens (1951) found that fermentation of overripe pods result in a lower percentage of purple beans than would be obtained by fermentation of ripe or under ripe pods.

Harvesting is usually carried out over a period of 3-4 days, at intervals of three weeks (Lopez, 1986). Pods are split open immediately after harvesting and the wet beans are extracted. Sometimes the harvested pods are kept for a number of days, in a process known as pod storage. This pod storage process will increase labour costs as it involves double handling and transportation of pods after harvesting. It also increases the risk of cocoa pod borer infestation (Day, 1985). Despite, the significant improvement in cocoa flavours after 4 days of pod storage, it is still not practised in larger plantations or farms in Malaysia and Indonesia (Arikiah *et al.*, 1994) because of these negative factors.

## Fermentation

Post harvest treatments such as pod storage, fermentation, drying and roasting are crucial in the formation of desirable chemical and physical properties. Fermentation is the first stage in preparing the cocoa bean for the market. The process of fermentation starts immediately after the splitting of the cocoa pod (Kim and Keeney, 1984). The whole process involves extraction of cocoa beans from the pods, the liquefication of the pulp caused by anaerobic yeast (Jinap, 1994) followed by the adherence of the cocoa pulp to the beans. These processes create the reactions necessary for the production of cocoa beans of high quality.

The basic requirement for satisfactory fermentation is that it should commence within 24 hours of pod splitting. It requires maintenance of heat, draining of sweatings and provision of an adequate and constant access to air (Wood and Lass, 1985). Fermentation temperature and constant access to air are not solely dependant on each other but is also influenced by fermentation batch size (Rohan, 1963). Any reduction in batch size is usually accompanied by an increase in the uniformity and rate of fermentation throughout the mass, but poses a difficulty with regard to insulation of heat. Throughout the fermentation process, the beans are normally turned once or twice for the purpose of aeration (Wood and Lass, 1985).