OCR
RECOGNISING ACHIEVEMENT

ADVANCED GCE

APPLIED SCIENCE

Sampling, Testing and Processing

G628

INSERT

Monday 7 June 2010
Morning

Duration: 1 hour 30 minutes

OCE/17807

INSTRUCTION TO EXAMS OFFICER/INVIGILATOR

- Do not send this Insert for marking; it should be retained in the centre or destroyed.

INFORMATION FOR CANDIDATES

- Questions 1 and 2 are based on the articles which follow on pages 2–5 of this Insert.
- This document consists of **8** pages. Any blank pages are indicated.

DC (SHW 00495 5/09) 17807/3

Chocolate – 'God food' or bitter water?

The cocoa tree, *Theobroma cacao*, originates from the Amazon basin. The fruit of this tree is used to make cocoa powder and chocolate. The earliest record of using cocoa as a drink is about 1500 years ago. The Mayan word for the cacao (cocoa) tree means 'God food' and the Mayan word for chocolate means 'bitter water'.

Theobroma cacao is an evergreen tree around 12 metres tall. It needs a humid climate and grows best at an elevation of 200 to 400 metres above sea level. The trees are not easy to grow and thrive best as an understorey tree. They also suffer from attacks by pests and from a number of diseases.

Mature trees produce about 20 pods (fruits) and, on average, it takes 20 pods to produce each kilogram of raw cocoa. The pods grow on the branches and on the trunk of the tree. The ripe pods are brown and weigh about 500 grams each. A pod contains 30 to 40 seeds (beans) embedded in a white pulp.

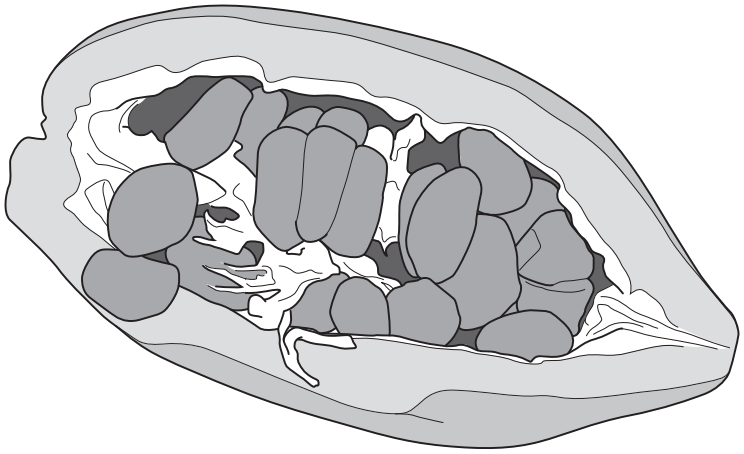


Fig. 1a

After harvesting, the pods are opened and the beans removed from most of the pulp. The separated beans are left to ferment for about 5 days, during which time they change from purple to brown. The fermenting process is important for the quality of the beans, which originally have a bitter taste. The beans are then dried, whereby they lose about half their mass, leaving them containing about 7% of moisture.

The beans are then roasted, when any bacteria present will be destroyed. Control of the roasting process requires great skill, as this is essential for the development of an acceptable chocolate flavour. High pressure liquid chromatography (HPLC) is a modern technique that can be used to analyse samples of the roasted beans to see if the optimum 'chocolate flavour' has been reached during the roasting process.

After roasting the beans are finely ground and pressed. This process removes much of the fat (cocoa butter) present in the seeds and leaves behind cocoa powder, which still contains around 20% of the cocoa fat.

Chocolate is made from various combinations of cocoa powder, cocoa butter and sugar. If milk chocolate is to be made, full cream milk powder is also used. An important part of chocolate manufacture is to make a product that is a solid at 25 °C but not too hard to bite through. The melting point of the fat, present in the chocolate, needs to be below body temperature (37 °C), so that the chocolate melts in the mouth. The particle size of the solids present in melted chocolate is also important. The particles need to be very small so that they do not give a gritty sensation when the chocolate is eaten.

The manufacture of chocolate needs many rigorous checks for acceptable quality. These tests include measurements of the viscosity of the liquid chocolate, its relative hardness and expansion. Problems with expansion may arise when the temperature changes during the storage of filled chocolates. The chocolate coating may crack if the contents expand at a different rate to the chocolate.

Chocolate is a complex mixture of materials. Two compounds present, caffeine and theobromine, produce significant psychoactivity when eaten. Caffeine and theobromine both stimulate the central nervous system, although theobromine is only about one tenth as effective as the same mass of caffeine in this respect. The amounts of these two compounds in various types of chocolate and in drinks are seen in Table 1a.

Table 1a

	amount	**caffeine/mg**	**theobromine/mg**
milk chocolate	25 g	10	70
plain chocolate	25 g	11	105
white chocolate	25 g	trace	0.5
strong ground coffee	cup	85	none
tea	cup	50	2
cola	can	40	none

One advantage of theobromine over caffeine is that it increases alertness but does not increase the heart rate.

The first chocolate bars were produced in about 1870 and the demand for this product has continually risen since then. In 2007, global sales of chocolate were 20% higher than in 2002. Around 45% of chocolate and confectionery containing chocolate is eaten in Western Europe with the United States contributing another 20%. There is scope for increasing chocolate consumption in Asia but whether cocoa growers can keep up with this continually increasing demand for raw cocoa is uncertain.

Tin – an element of history

An examiner once asked on an A Level paper – 'Why did the Bronze Age occur before the Iron Age?' The answer is related to the ease with which copper and tin (found in bronze) and iron can be extracted from their ores. Copper and tin are made easily from their ores at comparatively low temperatures whereas iron needs a much higher temperature for it to be obtained from iron ore. Tin was added to copper to make bronze because it made the 'copper' much stronger. This enabled more effective spears to be made for hunting.

Cassiterite (tin(IV) oxide) is the main ore from which tin is made. In Cornwall, tin was first extracted from its ore around 4000 years ago. Tin ore is found as veins in rocks from which it can be mined, or as sediment in the bottom of streams (alluvial tin). Tin ore is obtained from stream sediments by panning in the traditional way. This technique is effective because the ore is much denser than most other rocks.

Tin ore is sometimes contaminated with other minerals such as iron pyrites, chalcopyrite and arsenical pyrites. This contaminated tin ore is firstly roasted in air, when sulfur dioxide and arsenic oxide are produced as toxic vapours. The remaining solid is then cooled and soaked in water. Any copper sulfate present dissolves in the water and any iron(III) oxide solid, which is less dense than the tin ore, can be washed away. The remaining tin ore is then heated with carbon in a furnace at 1200 °C, to produce tin as a liquid (melting temperature 232 °C).

Despite tin being a relatively uncommon metal it has a great variety of uses. Canned food was introduced in the 19th century and, although some people refer to them as tin cans, most cans are made of steel with a very thin tin coating to prevent the contents attacking the steel. There is a problem about traces of tin leaching into the contents and people who eat a lot of canned food can absorb as much as 1 mg of tin per day. Fortunately, tin is not a particularly toxic metal. Even so, many cans nowadays have a coating of lacquer inside to reduce the amount of tin that can leach into the food.

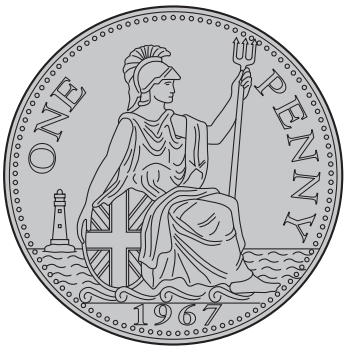
Canned meats were an important feature of voyages of exploration before the use of refrigeration. Some of these early voyages ended in disaster, not because of the tin present, but because lead was in the solder used to seal the cans and this caused lead poisoning. Since many cans still have a tin coating there is scope for recovering the tin present. The cans are cleaned, dried and then treated electrolytically to remove the tin. Alternatively chlorine gas can be used to react with the tin, giving tin chloride from which pure tin can be obtained. The tin coating is only about 1.5×10^{-6} m in thickness. Around 100 million (1×10^{8}) cans are produced every year and around 30% of these are recycled for their tin content.

Tin has a number of important uses when it is alloyed with other metals. Some of these are seen in Table 2a.

Table 2a

alloy	composition
bronze	tin 10% copper 85% zinc 5%
bell metal	tin 24% copper 76%
dental amalgam	tin 27% copper 13% silver 60% in mercury
organ pipes	tin 30% lead 70%
solder	tin 33% lead 67%
pewter	tin 85% copper 7% other metals 8%

In the past, British bronze coins have always contained a little tin. Before decimalisation in 1971 a British penny (1d), Fig. 2a, contained copper 95.5%, zinc 1.5% and tin 3.0%. However, tin is a scarce metal and both demand and price are always rising. The decimal penny (1p) contained less tin; 97.0% copper, zinc 2.5% and only 0.5% of tin (Fig. 2a). Since 1992, tin has been removed altogether and 1p coins from that date are made of steel with a thin copper coating.



pre-decimalisation
one penny (1d)

decimal
one penny (1p)

silver penny
of Henry I

Fig. 2a

The alloy of lead and tin used for making organ pipes is important for the quality of the sound produced. The frequency, *f*, of the note from organ pipes is related to the length of the pipe, *l*, by the formula

$$f = \frac{v}{2l}$$

where *v* is the velocity of sound in air.

The compounds of tin have a chequered history. Some have been used to society's advantage but others that have been used have proved to be toxic, leading to severe ecological problems. Some fluoride toothpastes contain tin(II) fluoride, as such tin compounds are not toxic. Many organic compounds of tin are toxic and hazardous in their use. Tributyltin compounds (TBT) have been used as fungicides in wood preservatives and in anti-fouling paints on the hulls of ships. However, even at very low concentrations, TBT causes serious harm to invertebrates such as shellfish. The use of TBT and similar compounds has, as a result, been severely restricted.

Tin can be added to silver, when making coins, to reduce their silver content. This process is called adulteration. In 1124, during the reign of Henry I of England, workers at the Royal Mint were accused of adulterating silver coins with tin. They were sentenced to have their right arms amputated. However, modern instrumental methods have shown that silver coins of this period contain only very slight traces of tin, so the workers were probably innocent! A silver coin from the reign of Henry I is shown in Fig. 2a.

Tin continues to be a metal for which there is a great demand but suffers from declining reserves and therefore recycling is becoming increasingly important.

BLANK PAGE

BLANK PAGE